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Electrolytic Copper and Lead Refining.

In an editorial note of our issue of last November we discussed copper smelting as a method of recovering gold and silver and gave some figures indicating the most remarkable growth of our electrolytic copper refineries. A suggestive new illustration of this development is the undertaking of the Mountain Copper Co., in California. This is a very progressive concern, as is indicated by the fact that as mine owners they became chemical manufacturers, producing sulphuric acid and selling fertilizers. They have a large new plant at Martinez, where the copper ores, after roasting and recovering the sulphur as sulphuric acid, will be smelted in the blast furnace with silver ores from Nevada, using the copper as a carrier for the silver. This is, of course, to be followed by electrolytic refining. In view of the growing Pacific trade of this country, it may be expected that the company will have full success as the due reward of its progressiveness. Another new and very interesting development in electrolytic refining is reported in the field of lead. The United States Mining, Smelting & Refining Co., owning the De Lamar Copper Refinery, in Chrome, N. J., copper smelters in California and lead properties in Utah, could not, it is said, make satisfactory terms with the American Smelting & Refining Co., and will now become its competitors by erecting a lead plant at Hammond, near South Chicago, in the heart of a good lead center. Mr. A. G. Betts' electrolytic lead-refining process—well known to our readers—will be employed. This will be the third large commercial application of this process, the first and oldest one being in Trail, B. C., the second in Newcastle-on-Tyne, England. The great purity of electrolytic lead and its freedom from bismuth are features of the process. If the carefully devised slimes treatment, described last year by Mr. Betts in our columns, turns out on a large scale as successful as is hoped for, the recovery of the values will be complete, and the Parkes process will be put most decisively on the defensive. In comparing electrolytic lead and copper refining, attention should be paid to the much higher electrochemical equivalent of lead, compared with copper. This means that the power cost will be a much lower item in lead refining than in copper refining.

Power Plant Economics.

A paper recently presented on power plant economics before the American Institute of Electrical Engineers, by Mr. Henry G. Stott, superintendent of motive power of the Interborough Rapid Transit Co., of New York, is exceedingly valuable and interesting. The first feature is the author's analysis of a modern steam-power plant from the coal to the bus-bars in the same way as it is now customary to analyze a metallurgical or chemical process on the basis of thermochemical principles. Mr. Stott's analysis is based on a year's operation of what is probably one of the most efficient plants in existence to-day, using reciprocating steam engines, and therefore typical of the

present state of the art. The total final result of his analysis is that out of the heat units supplied in form of coal, 10.3 per cent are delivered to the bus-bars in form of electrical energy. Almost 90 per cent are, therefore, lost, but it is most interesting that of these total losses the whole electrical losses do not amount to more than three-tenths of 1 per cent. This point is significant, since it indicates one of the chief underlying reasons which have made the modern electric power development possible. The electrical equipment itself, the design of generators, transformers and motors has practically reached ideal perfection, as far efficiency is concerned. It is this efficiency of the electrical equipment, together with its flexibility, which lies at the bottom of our systems of electric power generation and distribution, and which has made possible the large modern "syndicate power plant" with its supply of power in bulk to a number of sub-stations. On the other hand, this fact should teach a lesson to users of electric power; in discussions of projects it is not unusual to make much of the superiority of one type of electrical machine over another type, the difference being generally something like 1 or 2 per cent. If we look on the power-plant as a whole, this difference will be perfectly insignificant in view of the above facts. To increase the efficiency of the power plant, we should learn to be satisfied with the electrical machinery as it is and to look for improvements in other directions.

* * *

Mr. Stott's energy balance sheet shows three large sources of loss. The loss in boiler radiation and leakage is 8.0 per cent, the loss of heat to stack is 22.7 per cent, and the heat rejected to the condenser amounts to 60.1 per cent. New methods of boiler setting may diminish the first loss. The loss to stack can be considerably diminished by the use of more scientific methods in the boiler room. Care should be taken not to admit too much air to the combustion chamber, and in this respect a CO_2 recorder, when watched by the fireman, has proven a very valuable instrument. The third and largest loss—the heat rejected to the condenser—is, of course, intimately connected with the thermodynamics of the reciprocating steam engine, and it is superfluous to dwell here on this point. The engine losses may, however, be somewhat reduced by the use of superheat. In the whole, Mr. Stott concludes that by applying judiciously the above remedies it will be possible to increase the total thermal efficiency from 10.3 to 14.44 per cent. A further important improvement may be obtained at a small cost by running the present types of reciprocating engines at high pressure, adding a steam turbine in the exhaust between the engine and the condenser. These methods appear to exhaust the present possibilities of the reciprocating steam engines. But, if we leave water-power plants outside of the realm of this discussion, there are now the steam turbine and the gas engine looming up as formidable rivals, and it is with respect to them that Mr. Stott makes some very interesting suggestions.

* * *

The steam-turbine plant has an inherent economy 20 per cent better than the best type of reciprocating-engine plant, not so much due to its higher thermal efficiency as to a variety of other causes; moreover, during the last years the steam turbine has shown itself to be able to do in serious actual work all that had formerly been claimed for it on paper. The advances made by the gas engine have been steady, but slower. It represents undoubtedly at present the most efficient motive power. Its mechanical defects have now been overcome, but there still remains that inherent difficulty—lack of overload capacity. On the other hand, the advances made in gas producers have been so remarkable recently and the possibilities of the use of the waste gases from blast furnaces are so great, as has been repeatedly pointed out in these columns, that a more rapid development of the use of gas power is bound to come in near future. Mr. Stott makes a simple, but ingenious suggestion concerning a combination of steam and gas power. A combination of gas engines and steam turbines working in multiple in a single plant offers the possibility of producing the kw-hour for less than one-half its present cost, and overcomes the disadvantage of lack of overload capacity of the gas engine. The gas engine will carry the constant portion of the load and the steam turbine the fluctuating load. Both types of machines are well adapted to do their share, and both will, therefore, be well adapted to work together for ordinary service. Such a technical combination of steam and gas would be quite in line with modern commercial developments, competition being replaced by consolidation.

Conditions in the Spelter Market.

It is extremely difficult to make anything but most vague and general prognostications about the commercial future of any metal. Metal brokers as a rule rely mostly on temporary conditions, such as "offerings" and "visible supplies," and base their diagnosis on daily symptoms rather than on the general physical tone of the body of the patient. Nevertheless, broad generalizations are always of value, if adherence is kept to the idea that anyone of several circumtsances may alter the case substantially. Now, in the zinc business, it may be remarked that the conditions are unique and radically different from those of any other metal. In the first place, in the past year over 60 per cent of the metal was produced from "concentrates" from the Joplin mines. In this ore market perfect and free competition exists. There are at times as high as 300 producing mines offering in the market zinc concentrates to the weekly value of $250,000. There are seven or eight smelting concerns who compete most strongly for the product of these mines. The scattered and "pockety" nature of the Joplin deposits causes the diversification of the mining, and cheap production is due to close personal attention of the mining boss. Hence, we do not have exhibited the centralization of management, which has been the well-nigh universal tendency of American industrial development in the past ten years, and cheap production is the criterion on which all "trusts" must be judged.

* * *

In the treatment of ores for the production of metal (zinc smelting is an absolute misnomer), the smallness of the unit, the 50-pound retort, produces exactly the same state of affairs. Conditions are such that despite the efforts of the irrepressible and buoyant promoter no "zinc trust" has been formed as yet, though strenuous efforts have been and are now being made to such an end. The final result is that free and open com-

petition, both in ore market and in the metal market, allow quick and free play of economic forces. Consequently we see, often in the price of metal, sharp weekly fluctuations as well as movements caused by underlying conditions. There are "choppy seas" and "ground swells" as well as large ocean currents. The character of the consumption of the metal is also unique. About half of the spelter of the country is absorbed by the galvanizing trade and about 30 per cent by the United States Steel Corporation alone. The steel business is proverbially a barometer of general trade, and it is apparent that the spelter business responds to the steel business with which it is so vitally connected. Therefore, the market for the metal is supersensitive and shows at once any slight recession or advance in the country's prosperity.

* * *

The advances in the metallurgy of zinc and in ore dressing have opened up the large fields of Wisconsin, Leadville, New Mexico, Utah, Montana and Mexico, so that Joplin is slowly but surely losing its pre-eminence as a factor in the market, though the camp is now and will be for some time most prosperous. In time, also, these efforts to consolidate several large companies into a "trust" will find success, for it is the logical outcome of the situation. Stability is always needed to ensure perfect efficiency of industrial production. With respect to the market, there are several general and broad reasons why the consumption of galvanized sheets and other forms of galvanized iron will increase in the future. First, manufacturing plants, now being built, are erected as permanent structures. This is due to the change of the United States to a country where solid construction is a paying proposition. We are no longer considering cheapness of the first installation as the prime requisite, but are looking for the highest efficiency for a long term of years. Thus galvanized sheets are used in larger quantities each year. In the next place, the general expansion of business has forced up the price of lumber inordinately. Galvanized sheets are, everywhere, the best substitute for wood. Indeed, Western farmers are using them at present for roofing both barns and dwellings. A third consideration is that spelter is usually consumed, and once leaving the metal-house is lost forever. Vast quantities of lead, iron, steel and copper return as "scrap" to the market, quite the contrary to the case with zinc. Taken in its entirety, the zinc business from the mine to the market is in good shape, and there is every indication that progress in the treatment of zinc ores will increase the production of spelter, so as to meet the large probable future basic demands.

The Old Pioneer Spirit of America Manifested in Our Life of To-Day.

Every American delights to "rough it" for a few weeks in each year. Contact with nature is a return to primitive conditions and, by the psychology of play, in camp-life atavistic instincts are allowed free play in the individual of any country. But especially, here in America we are all descendants from pioneers, from men and women who dared break away from fixed society of Europe and settle in a country of unknown terrors. This "selection of emigration," as we may term it, has brought about a nation in which all the best and most adventurous blood of the world has been centered. Thus, we are, as a nation, strong, courageous and resourceful. Now, the immortal spirit of the colonists lives in their descendants. And it is but natural that life in the woods with knife, axe, rifle and frying-pan delights the true American. This same spirit, seen in our play, is also seen in our everyday work. It is our real national genius—a genius peculiarly our own. The same pluck and intelligent daring that pervaded the minds of Lewis and Clark in their expedition to Oregon cropped out, an every-recurring vein of richness, in the formation of the gigantic United States Steel Corporation. The same fighting blood that enabled some poor farmers and backwoodsmen at Bunker Hill and later at New Orleans to repulse and shatter the flower of the English army is seen on the football field, where our young men gladly risk life and limb to uphold the honor of some modern monastery of learning—a strange disharmony of endeavor. This same daring and bull-dog grit evidenced itself in our dreadful fraticidal Civil War, and also in Dewey's "walk-over" at Manilla. In all philosophy, there is unity and the persistence of this pioneer strain in America is in accordance with the general nature of things.

* * *

In metallurgy, as well as in business, we find the same spirit of the pioneer. It takes no whit less courage to build a blast furnace that makes in a day 950 tons of pig iron than to open up a new country and repel the Indian raiders. Life in the backwoods develops resourcefulness and ingenuity. The men whose fathers built mills entirely of wood, wooden pins, shafts, gears, etc., make the automatic charging machine for the open-hearth furnace. The patent office is filled with the ideas of the national pioneer mind, working to-day throughout our whole land. We would also trace that imaginative and spiritual quality which is our best trait to the close contact that the leaders of our thought and life have ever had with nature. The modern artistic triumphs of America, such as those of Whistler, Sargent, St. Gaudens and MacMonnies show the freshness and originality of youth. It is, however, in human achievements rather than in expression of human desires and crises that America shines. No one who has ever seen the bones and tufts of hair of the lonely prospector bleaching beside those of his faithful horse, needs any picture to call up the sadness of life. He knows the real thing. To the old age of a nation belongs the flower of expression and art.

* * *

In new developments and in new enterprises the influence of America's early struggles is apparent. It is no mere material achievement to unite two large copper furnaces and put through that new furnace 1,500 tons of ore. It is the triumph of an idea, and German philosophy has taught us the persistence of the ideal in everyday life. The mammoth mining in the Mesabi iron district is another instance of projected and youthful imaginations, of our quick readiness to make a change and "to do something big." Optimism, cheerfulness and physical strength (our nation consumes enough patent medicines to kill us all) are typical characteristics of America, but especially of the growing, noisy and lovable West. "In the bright lexicon the world calls youth, there is no such word as fail." We are as a nation youthful, and our faults are those of crude, virile youth. But we do not intend to fail.

A. E. S. Election.

In our correspondence columns we print two letters, one by Prof. C. F. Burgess and the other by Mr. C. J. Reed, requesting that they be not considered candidates for the presidency of the American Electrochemical Society. We join Prof. Burgess in the hope that Mr. Carl Hering, who received the largest number of nominating votes for president, will be chosen as the next president by a practically unanimous vote, to which he is entitled as one of the founders and most active members of the Society. It is hoped, however, that the Society will not be entirely deprived of the services of Prof. Burgess and Mr. Reed on the Council. Since their terms as vice-presidents will expire this Spring, they cannot, according to the constitution, be re-elected vice-presidents, but are eligible for election as managers. In view of the persistent and able work which they are doing for the Society and for the profession which it represents, it probably can be taken for granted that those who proposed Prof. Burgess and Mr. Reed this year, will, with many others, put forward their names at future dates for the presidential nomination.

The Electric Furnace of Heroult for Iron Reduction at the "Soo."

Our readers are well acquainted with the praiseworthy and systematic endeavor of the Canadian Government to test the possibilities of the electric furnace in the metallurgy of iron and steel, with a view of making both the water-powers and iron ores of Canada available for a new important industry in that country.

As has already been mentioned repeatedly in our columns, the experimental tests which are being made at Sault Ste. Marie under the direction of Dr. Paul Héroult, of La Praz, France, and under the supervision of Dr. Eugene Haanel, Superintendent of Mines, Ottawa, representing the Canadian Government, relate to the broadest and most difficult problem of applying the electric furnace in the iron and steel industry, namely, for the reduction of iron from the ore. It is the more gratifying to read the following telegram, which is reported to have been sent by Dr. Haanel on Feb. 24, to Hon. Frank Oliver, Minister of the Interior, Ottawa, Can.:

"Successful demonstration of all points stated in my memorandum on electric smelting of Canadian iron ores requiring investigation. Output greater than figure adopted by Harbord in report of Commission. Successful smelting of magnetite and desulphurization of pig. Successful substitution of charcoal, and, therefore, of peat, for coke. Consumption of electrodes insignificant. Production of nickel pig of fine quality from roasted pyrrhotite. Forty tons of pig have so far been produced. Process admits of immediate commercial application. Experiments will be completed in about two weeks."

More detailed accounts of the experiments are not yet available for publication. The figures of the report of Harbord, referred to in the above dispatch, were published and discussed in our issue of Dec., 1904, page 483 and following.

Thermochemistry of Chemical Combination.

In an interesting paper, recently presented by Prof. J. W. Richards before the American Chemical Society, the pertinent question is proposed: The combination heat of H_2 and O is 56,683 calories to vapor, 69,000 to liquid, 70,440 to solid water; which of these represents best the true chemical heat of union of the elements? Dr. Richards' answer is: The first, since the second and third figures contain amounts of energy of purely physical origin, namely, the latent heats of vaporization and of fusion. In general, comparisons and discussions of thermochemical data should be made on the basis of the heat evolved in the combination of the *solid elements* to the gaseous products. As a further refinement, correction should be made for the external work done when the gaseous product is formed, $Q = 2T$. But even then the temperature is still arbitrary, and the ideal way would be to refer the combination heat to the zero point of absolute temperature.

The second part of the paper deals with a discussion of the formation heat to dilute aqueous solutions and the well-known additive law which holds there. On this thermochemical basis Prof. Richards points out that the inference is inevitable that the state of being in dilute solution is "the state of most uniform chemical combination." Very complete tables are given of the "constants of heat of chemical combination." To call them ionisation heats, as Ostwald does, is a misnomer, according to the author.

Tendencies in the Foundry Industry.

Dr. Richard Moldenke, the ever active secretary of the American Foundrymens' Association, delivered a suggestive paper on this subject before the New England Foundrymens' Association in Boston.

In his introductory remarks Dr. Moldenke emphasized that there is manifest to-day a tendency toward refinement in method, little dreamed of by the most ardent iconoclasts of a decade ago. Perhaps our peculiar situation in this country, where the foundry is engaged in pushing specialties to the limit, has enabled us to take the lead in many directions. Great stress is laid, in our strictly modern establishments, upon system and organization, and there is a strong tendency towards specialization of our shops. Since specialty work means the production of the same casting in very large quantities, we can see why machine molding in its various phases is beginning to play such an important rôle. There is also a noticeable tendency to economize shop room, and hence, molds are piled as high as they can be conveniently poured. Dr. Moldenke suggests that the idea should be followed out to its logical end wherever work is made in sufficient quantity. This would seem to be the stacking up of the molds in fairly deep foundry pits, the iron being brought in large ladles by traveling cranes and poured from the bottom of the ladle.

Greater attention will ultimately be given to the preparations of the molding sand. "Our European brethren are far ahead of us in this respect, every foundry of importance grinding its sand to a given standard, then passing it through mixers, which incidentally fill the perfectly uniform material with a maximum of air, thus cushioning the sand and keeping it as open as it may be. When a highly refractory molding sand is used, this treatment assists in turning out the smoothest kind of work."

Dr. Moldenke then referred to the growing tendency to perform as many operations about the foundry as possible by mechanical means, and also mentioned the growing demand for foundry standards. The makers of molding machines will be greatly benefited by the desired standardization of flasks.

Turning to the melting and the closely allied laboratory, Dr. Moldenke pointed out that the strongest marked tendency of the day in the industry is the production of higher grade castings by the addition of steel scrap, or in other words, the reduction of the total carbon in cast iron, making the crystalline structure more closely adherent, and hence the whole casting stronger. Here the skill of the melter is joined with that of the chemist, so that value is received from the higher priced stock charged into the cupola. The cupola process is being studied more carefully, and experts in that line can produce results close to those of the air furnace, or open hearth.

This tendency has somewhat retarded the introduction of air furnaces in general foundry practice. However, taking into consideration the demand for better irons, better coke, better melting methods, the specialist founder will soon tire of buy-

ing high-class material and taking big chances in spoiling it. He will naturally revert to the air furnace as better able to give high-class results from high-class material, and the consumer will be glad to pay the difference.

Whereas, once the melting point of the various cast irons formed the one absorbing topic for articles and discussion, at present it is the elimination of sulphur in the cupola. This is a good sign, and even if one man finds that he cannot get the results of the other, and therefore we are at present quite at sea regarding a desirable method, yet it shows a tendency, and a good one.

With more light on this question, it is but a step to work on others, and finally we may get down to a closer study of the burning effects manifested in cupola and air furnace practice, which Dr. Moldenke holds, are the most important by far of all the phenomena of the foundry melting processes, granted that the chemical composition is otherwise correct.

This leads to the use of the ferro-alloys in the foundry to correct the evils we know, and others we have a vague apprehension of. To-day the use of ferro-manganese and of aluminium is quite extended, and is really a help in many instances. With the poor pig-iron, and especially the very poor coke the smaller founder is forced to put up with, the use of either of the above mentioned correctives is to be recommended. Unfortunately ferro-manganese is hardly powerful enough to do much good in the foundry, unless the mixture has a goodly proportion of steel in it. This means a higher melting point, and with higher temperatures than ordinary cast iron is apt to be poured at, much of the oxidation is removed, and we avoid the pin holes, other weakening and unsightly effects, which seem to be somewhat the rule at the present day. "The real foundry alloy, however, is still to be discovered and made commercially, and the day cannot come too soon for this desideratum to be realized."

Dr. Moldenke looks forward to great improvements in the making of producer gas. Whoever has worked with gas instead of coal, will stick to the former until the price soars out of sight. Just how this tendency will work itself out in the foundry is hard to say. Whether it means the use of the open-hearth furnace in the big foundries, or the making of electricity with the gas engine in the smaller foundries for use in melting, time will determine, but it is well to keep this development before us, and to profit thereby.

This led up to the consideration of electric smelting. "The Canadian Government is doing much to foster the development of electric smelting. The makers of the latest types of electric furnaces are constantly getting better efficiencies. Now, with a cheap gas, in a gas engine, and for the making of very small castings in small quantity, there is no reason why the small steel, malleable, and even gray casting industry, not to speak of the brass and bronze contingent, should not melt their stock in the electric furnace. The higher price of the work sold will probably stand this. This tendency will bear watching. I have recently noticed a neat suggestion by Dr. Waldo along this line, where he proposes to make Bessemer steel rings, or suitably-shaped small ingots, these to be of the composition of the steel casting. Now, by charging these small ingots into the electric furnace, one obtains a fluid steel of the proper composition to cast. I would suggest as an improvement that the ingots be pre-heated up to the highest point possible, without injury to the metal; say just as the ingots for rails or structural steel are treated. This would leave for the more expensive electric current only the finishing heat, necessary to melt and superheat to the point right for pouring."

Finally, Dr. Moldenke discussed the general problems of the foundry, in which there are also marked tendencies for a change. This will probably affect only the very large industries for the present and next generation, but what may come after is hard to say. Foremost stands the rapidly increasing use of direct metal. "This is more marked across the water, but is bound to come here also. The big segments for the tunnel shields and linings should never have been made of remelted metal. However, this does not mean that it was advisable from the first to jump into a new method for such vast contracts. Here again, we strike the importance of the use of steel scrap in gray-iron castings, in order to reduce the total carbon. I would not advocate the use of direct metal just as it is, but to have the stream of metal from the blast furnace go into large heated mixers, which means greater, in fact, more easily attained uniformity than is ever possible with the cupola. Now, into this mixer there should be charged successively, quantities of steel scrap which has been heated up to almost melting. This accomplishes a two-fold purpose. First, it gives a reduction of total carbon without lowering the temperature of the metal in the mixer too seriously not to be corrected at once by the heating method used as well as the comparatively large quantity of metal that should be in the mixer all the time. Now, the first result is the making of a high-grade cast iron. This iron should be good enough for all the purposes the process could be used for, such as the making of pipe, tunnel segments, ingot-molds, etc.

"The second effect of the addition of the preheated steel scrap is that the problem of 'kish' is done away with. This is the bug-bear of the direct metal foundry, and in fact has retarded the introduction of direct metal for important work so much that at one time it was thought out of question to think of ever going back to this century's old way of making castings.

"What then will be the result of this tendency? It means that blast furnaces will be located wherever the raw material not only are favorable, but where there is a good shipping point for pipe, possible car wheels, and not impossible, malleable castings for car work. The furnace proposition will then become one of allied industries to give an outlet for the pig-iron made, which will fit these uses, and all the pig iron not of composition to go into the various mixers will be put upon the market. While this seems visionary, it is nevertheless a fact that one very large combination is about to break ground for just such an establishment, and we may hear from direct metal pipe very soon."

CORRESPONDENCE.

A. E. S. Election.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—Will you please announce my request to the members of the American Electrochemical Society that my name be withdrawn from the list of nominees for the presidency of the American Electrochemical Society. I am impelled in making this request by the hope that Mr. Carl Hering will be chosen as the next president with a practically unanimous vote, such as his effective and enthusiastic services in the organization and conducting of the Society entitles him to. I am further impelled by knowledge that should the remote possibility of my election to the office be realized, it would be impossible for me to administer the duties thereof during the coming year in a manner such as the needs of the Society require.

MADISON, WIS. C. F. BURGESS.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—Will you kindly announce through your journal my declination of the nomination for president of the American Electrochemical Society, as it would be impossible for me to serve if elected. My declination would have appeared on the official circular had the usual opportunity been afforded. I did not know that my name was to appear as a nominee until after receiving the printed circular, and I take this as the only available means of notifying my friends not to waste their votes. C. J. REED.

PHILADELPHIA, PA.

A Co-operative Analysis of a Copper Slag.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In the February issue of this journal you print my reply to Mr. Thorn Smith's article on the above subject (wherein he severely criticizes my zinc method) and Mr. Smith's rejoinder thereto. As I still maintain my position at every point, I feel I am fairly entitled to reply to Mr. Smith's latest statements.

I decline to admit any "difficulty or misunderstanding" in the matter of precipitating copper with aluminium. Materials may doubtless be encountered that present difficulty when treated by my regular method, but Ducktown slag is not one of them. True, I cannot take an unusually large amount of the slag and precipitate the copper therefrom in 7 minutes by my regular method, designed for the treatment of 0.5 gram. I can, however, take 0.5 gram and do so, as demonstrated by actual experiment.

If I desire to start with a larger amount of such material I may vary the method to correspond. For instance, taking 1 gram of Ducktown slag, the addition of 2 grams of 20-mesh zinc to the usual precipitating arrangement results in the complete precipitation of the copper in 7 minutes' boiling. The zinc is quickly dissolved, and serves mainly for the rapid reduction of the large amount of ferric iron in the solution.

Mr. Smith does not consider 0.5 gram of slag a sufficient amount to take. I beg to differ on this point. My results are sufficient evidence of the correctness of my position. Three determinations show an extreme variation of only 0.02 per cent, viz.: 0.85, 0.83, 0.85. Mr. Smith reports 0.81 per cent copper on the same sample. It may be of interest to know that my last determination required just 36 minutes from the beginning of the weighing to the end of the final calculation. If 1 gram is taken and put through in the same time, no zinc being used, the precipitation of the copper on aluminium is not entirely complete, hydrogen sulphide showing a plain brown coloration, but the final result is the same.

In the matter of zinc determination, Mr. Smith quotes Rueger and Furman as stating that the ferrocyanide method fails to give concordant results with small quantities of zinc, Furman placing the minimum at 4 per cent, using 1 gram of material, which is equivalent to 8 per cent on the basis of 0.5 gram. My own experience is quite the reverse. On the basis of 0.5 gram of material I have found no difficulty in determining known quantities of zinc as low as 0.5 per cent to within 0.10 per cent. There is evidently more than one way to conduct the method.

Mr. Smith claims that his criticism of my method was based on the results of the "zinc committee" and not on those of the slag analysis. I am quite willing to accept Mr. Smith's statement as evidence of his intentions, but his article unmistakably reads quite to the contrary. His severe condemnation of my method is in one paragraph, wherein only his own set of results is under consideration, and no mention of the results of the zinc committee is made until the following paragraph. As the article actually stands, his subsequent inconsistency is an undeniable fact.

Referring to my record of the close agreement between duplicates, Mr. Smith observes that this does not prove the infallibility of the method. Such an observation is entirely superfluous, as no such claim was made or implied. I had previously stated that the accuracy of the method was demonstrated by tests on mixtures of known zinc contents, and the close checking of duplicate determinations was plainly given to show the capabilities of the method in "everyday work," of which Mr. Smith had spoken so disparagingly.

My statement that No. 4 was classed as "fair, but hardly satisfactory," instead of No. 14, is due either to a typographical error or a mistake in transcribing from my original manuscript, where the reference is to No. 14.

Denver, Col. A. H. Low.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In Mr. Smith's recent report, which appeared in the November and December issues of this journal, reference is made to my method for the direct estimation of alumina. It may interest some of your readers to have my comments upon his method, more especially as Mr. Albert H. Low also mentions it in his recent excellent book on "Technical Methods of Ore Analysis."

Experience with the method since its publication has borne out its claim to accuracy, at least in my hands. However, my original expectations of its becoming a technical method are not likely to be realized, partly because it is not sufficiently rapid, but mainly on account of the difficulties which some chemists experience in operating it successfully. Mr. Low, for instance, states: "My own trials with this method have not proven satisfactory." Nevertheless, if properly performed, the results are correct, and it will check closely an alumina determination by difference. It is, of course, assumed that the latter method is also properly performed, which is frequently not the case.

It is not my intention to take up valuable space by again describing this method, which appeared in the *Engineering and Mining Journal* of March 3, 1904. However, for the benefit of those not familiar with it, I may mention that the alumina is precipitated by means of sodium sulphite from a solution very faintly acid with HCl. The assumed reaction is $Al_2Cl_6 + Na_2SO_3 + H_2O = Al_2(OH)_6 + NaCl + SO_2$. It is, therefore, analogous to Woehler's hyposulphite precipitation. The liberated sulphur dioxide naturally reduces the iron to the ferrous state. The success of the method depends on a rather nice degree of acidity, and this is undoubtedly the point where some chemists fail in reaching the correct conditions. Simple as these conditions are when once acquired, it seems difficult to convey an adequate description of them. I shall herein make an effort to clear up this stage of the procedure.

We will assume that the iron and the alumina are in solution as chlorides. The solution must be perfectly cold. Nearly neutralize the free acid with sodium carbonate until a slight tinge of light brown appears, but not to a port wine color. Now add a large excess of sodium sulphite, which on stirring will produce a precipitate. The solution and precipitate leave a deep red-brown color. The addition of HCl will gradually dissolve this precipitate until a port wine color is reached, and the solution shows signs of clearing. At this point HCl should be added slowly, drop by drop, with very thorough stirring, until the color of ferric iron shows signs of fading and the solution just clears. The odor of sulphur dioxide will now be faintly perceptible, and upon heating to boiling the color of ferric iron will rapidly disappear. The alumina should commence to precipitate on or before the boiling temperature is reached, otherwise the solution is too acid. Much material contains titanium, flocks of which will remain after the alumina has gone into solution. This is likely to mislead the operator inexperienced in this method into adding too large an excess of HCl. Probably the best way of becoming familiar with the scheme is to experiment upon solutions containing only alumina until the eye becomes accustomed to the necessary conditions for complete precipitation. The filtrate can then be tested with ammonia and ammonium chloride.

Incidentally, it may be remarked that this method has certain scientific possibilities in that it seemingly gives a sharp group separation of alumina, titanium, thoria and zirconia from the balance of the earths, although its limitations in this respect have not been fully confirmed by the writer.

Great Falls, Mont. Chas. E. Rueger.

BETHLEHEM MEETING OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

The ninetieth meeting of the American Institute of Mining Engineers was held in the Bethlehems from Feb. 21 to 24. The programme included professional meetings on Feb. 21 and 22, a reception and ball on the evening of Feb. 22, and two all-day excursions on Feb. 23 and 24. The pouring rain of the first evening washed away all the winter snow that was still some inches high on the campus of Lehigh University, and on the following three days of the convention the most delightful spring weather was enjoyed.

For the excellent arrangements and for the resulting success not enough credit can be given to the various local committees, all of which did splendid work. It is impossible to mention everyone who contributed to the success of the meeting and to the comfort of the visitors, but the names of the officers of the general local committee shall be given: Mr. John Fritz, chairman; Major A. B. De Saulles, of the New Jersey Zinc Co., vice-chairman; Mr. R. M. Bird, of the South Bethlehem Steel Co., treasurer; President Henry S. Drinker, of Lehigh University, secretary.

PHOTOGRAPH TAKEN ON THE EXCURSION OF FEB. 24, AT THE WORKS OF THE INGERSOLL-RAND CO.

Opening Meeting on Feb. 21.

The opening session was held on the evening of Feb. 21 at Lehigh University. An address of welcome by President Drinker and a speech by the president of the Institute, Mr. James Gayley, opened the proceedings. Then followed, according to the usual practice of the Institute, the presentation of biographical notices of prominent members, recently deceased; namely, a sketch of the life and work of George H. Eldridge, by Dr. S. F. Emmons, Washington, D. C., and biographical notices of Edward Cooper and of Alexander B. Coxe, by Dr. R. W. Raymond.

Mr. Howard W. DuBois, of Philadelphia, presented a very interesting address on British Columbia and Alaska, which was illustrated with colored lantern views of scenery, mining operations, etc. Mr. DuBois was professionally engaged in extensive explorations in the Northwest (the technical and geological sides of which were covered more fully in a paper presented by him at the meeting the next afternoon), and being a skillful photographer he took many pictures of extraordinary beauty and interest, which were colored under his direction by the foremost artists in such work. The exhibition of these pictures was greatly enjoyed by the audience, which numbered some 200 or 300.

The evening closed with a delightful informal reunion and reception on the invitation of Lehigh University.

Professional Meetings of Feb. 22.

The two meetings, held in the morning and in the afternoon of Feb. 22, were devoted to the presentation and discussion of papers. Both meetings were held in the Physical Laboratory of the University. After the morning session a luncheon was given by the University at the gymnasium, and in the interval between luncheon and afternoon session an opportunity was provided for the inspection of the buildings, laboratories, etc., of the University. Prof. J. W. Richards conducted the visitors through the Chemical Laboratory, with its specially fine electrochemical and electrometallurgical equipment, while at the Physical Laboratory, Prof. W. S. Franklin was constantly drawing a crowd by demonstrations of the speaking arc lamp and other experiments.

Most of the ladies attended in the forenoon an oratorical contest of students, held at the University Chapel, in connection with the celebration of Washington's birthday. One

lady—who, of course, did not belong to the Institute party—came by mistake to the Institute meeting. After having listened for some 15 minutes to a discussion of dry blast, per cents of saving of fuel, etc., she turned somewhat in disgust to an interested listener nearby, and asked: "This isn't the oratorical contest? Is it?"

Dry Blast.

The first paper of the morning session was presented by Mr. C. A. Meissner, and was in form of a discussion of Mr. James Gayley's famous paper on the application of dry-air blast to the manufacture of iron. Since Mr. Meissner is the engineer of the United States Steel Co., in charge of the Gayley dry-blast experiment, his account of the results of practically three years working of the system on a commercial scale will be read with much interest, when available in print. The results may be summed up briefly in the statement that the experience of three years has confirmed all that has been claimed for the method by Mr. Gayley.

The paper elicited considerable discussion, in which Prof. Henry M. Howe, Dr. R. W. Raymond, Dr. J. W. Richards and Mr. James Gayley participated. Some remarks of Mr. Gayley were of historical interest, showing his farsightedness at an early date. While others had only considered the saving of fuel necessary for the decomposition of the moisture of the blast, and thus calculated a possible saving of 3 per cent of fuel (or under special conditions a saving of 7 per cent), Mr. Gayley was from the start more concerned in the indirect savings due to the regularity of working of the furnace. When the experiment was undertaken, Mr. Gayley guaranteed a saving of 12 per cent; personally he expected 15 or 16 per cent; he obtained, as is now well known, 20 per cent.

Where does this saving come from? As Prof. Howe emphasized, a statement to the effect that the saving is due to the regularity of the working, is no real explanation. Dr. Raymond thought that metallurgical furnaces are not such ideal apparatus as to permit exact mathematical analysis, since they have fevers like human beings, and in times of "fever" some suppositions of the analysis are reversed. Prof. J. W. Richards sided with Prof. Howe, and then proceeded to give the different items to which the saving of fuel is due. His theory has already been given on page 240 of our last volume, to which the reader may be referred. Dr. Richards showed that in his analysis the only item which needed further explanation was the saving of 7 per cent, due to better combustion of carbon. This, he explained, is due to a higher temperature being available in the region of the tuyeres. Carbon is saved not for reduction but for producing a higher temperature. The important point is the increased smelting power at the tuyeres. Prof. Howe quite agreed with Prof. Richards' explanation, which he stated in a somewhat modified form.

Piping in Steel Ingots.

A paper on this subject was presented by Mr. N. Lilienberg, of Philadelphia. The author first discussed briefly several methods of keeping the steel liquid as far out towards the mould as possible, in order to get an even sinking of the top surface. The chief part of the paper dealt, however, with the methods of compressing the steel in the moulds. There are three methods of this kind: pressing from the top, from the bottom, from the sides. In the last method the top is left open, permitting the gases to escape, and the pressure is applied directly in proportion to the formation of the pipe, so as to keep the ingot always full to the top. It is obvious that the pressure can be better timed in this way than in the other two cases.

The author then gave a review of the work of Mr. John Illingworth in developing a practical method of the last type just mentioned; he stated that this work has now been completely successful. Mr. Illingworth, together with Mr. S. Robinson, has built casting machines for compressing large-sized ingots, cast from a ladle, at the steel works of Jessop & Sons, Sheffield, England, turning out uniformly ingots of the largest size, absolutely solid from top to bottom. There are two kinds of casting machines, one for large and the other for small ingots.

The principle is to cast the steel in molds divided in halves and held together, during the casting, by hydraulic pressure. In the planed side-edges of the molds are grooves which admit bars. After the metal has been poured into the mold, sufficient time is allowed for a crust to form while the interior is still liquid. The bars are then withdrawn by chains suspended from an overhead hoist, which leaves an empty space between the two halves of the mold. Hydraulic pressure is then applied from a ram, and the outer half of the mold is moved forward slowly so that the liquid interior is always kept full to the top until the mold is closed. The volume of the bars corresponds as near as possible to the volume of the cavities which would otherwise be found.

In the discussion which followed, Prof. H. M. Howe objected to the explanation of the formation of pipes as contraction cavities, and emphasized that on the contrary they are expansion cavities. Solid steel floats on molten steel, because the former is lighter, hence the passage from molten to solid steel is an expansion. The formation of pipes in steel ingots is the same as in ice blocks. Take a molten portion of steel inside a solid steel mass; pipes will result, according to Prof. Howe, if the expansion of the outside outruns the expansion of the inside.

The Aluminium Industry.

Prof. J. W. Richards, of Lehigh University, then spoke on the development and present status of the aluminium industry. In view of his connection with this industry he was not at liberty to present a printed paper; his lecture was therefore oral only, very concise, yet full and most interesting, and was highly appreciated. On account of the author's position, as he stated it himself, it is to be regretted that some unpublished interesting details which came out in his lecture will remain unpublished.

Dr. Richards first pointed out that the metallurgy of aluminium differs from the treatment of other metals in one important particular. With other metals reduction comes first, and the metal thereby produced is later refined. With aluminium we have not yet a method which has proven commercially successful for the purification of impure aluminium. In the aluminium industry the first step is, therefore, purification of bauxite, which is then followed by electrolytic reduction of aluminium.

Dr. Richards then gave a very appreciative sketch of the work of Charles M. Hall, and discussed both his methods of purifying bauxite and of producing metallic aluminium by electrolysis of fused baths. The reader may be referred to former articles on this subject in our journal, especially in our Vol. I., pp. 49 and 158. The commercial revolution in uses of aluminium, due to the price reduction, brought about by the application of electrochemical methods, was most happily brought out by the speaker.

Papers on Mining and Geology.

The papers presented at the afternoon session dealt with subjects of mining and geology.

Dr. R. W. Raymond first read a paper by Dr. A. R. Ledoux, on a novel method of mining kaolin from deep deposits. The method consists essentially in disintegrating the kaolin in situ by jets of water and then floating it to the surface. The paper was not discussed.

Mr. Howard W. DuBois presented a paper on the reconnaissance for the platinum metals in British Columbia. The paper was fully illustrated by lantern slides and aroused much interest. The speaker referred to the enormous increase in the price of platinum in recent years, and expressed the opinion

that new rich sources of platinum would become available in the near future in British Columbia and Alaska.

The paper was discussed in various respects. Prof. J. F. Kemp, of Columbia University, referred to the recent investigation of various black sands by the United States Geological Survey, and expressed the hope that these black sands would turn out to become a valuable commercial source of platinum.

The last paper of the meeting was presented by Mr. THOS. T. READ, the subject being the secondary enrichment of copper-iron sulphides. After that Dr. Raymond, as secretary, made some announcements and gave some interesting and amusing personal reminiscences of Detective McKenna (McParlan), so successful in detecting mining crimes, recently as well as some twenty years ago.

RECEPTION ON EVENING OF FEB. 22.

A most delightful reception was given in the evening by the citizens and industrial establishments of the Bethlehems and Lehigh University. The old historic Sun Inn in Bethlehem was entirely occupied for the occasion by the Institute and its guests. The reception took place in the large hall on the third floor, refreshments being served on the second floor. Dancing began at 10 o'clock. The hostesses of the evening were Mrs. Robert H. Sayre, Mrs. Henry S. Drinker, Mrs. E. M. McIlvain, Mrs. A. B. De Saulles, Mrs. John Fritz, Mrs G. B. Linderman, Mrs. Charles M. Dodson, Mrs. A. B. Fichter and Mrs. William B. Myers. It was a representative gathering of American beauty and brains.

EXCURSION OF FEBRUARY 23.

On Friday morning the members of the Institute and their guests took bright and early, a special train, courteously provided by the Jersey Central Railroad, and first went to Palmerton, near Hazard, to inspect the large plant of the New Jersey Zinc Co.

HAZARD ZINC WORKS.

The New Jersey Zinc Co., as is well known, is the strongest factor in the zinc business of the United States, and is equal in size and importance to the celebrated Vieille Montague, of Belgium. Its plant for the production of zinc oxide and spiegel is at Newark, N. J., but at the present time only the spiegel furnace is being operated. It also has a spelter plant, zinc oxide plant, and a small spiegel furnace at South Bethlehem, Pa. In the South it has a spelter works and mines operating as the Bertha Mineral Co., at Pulaski, Va. At Mineral Point, Wis., in the Wisconsin zinc fields, it has a large oxide plant, and also an acid plant using the zinc sulphide ores of this district. At this plant sulphuric acid is produced by the Grillo-Schroeder process. It has also a spelter works at Waukegan, North Chicago, and operates in Gas City and Iola, Kan., three large spelter works. At Cañon City, Col., it operates an ore-dressing plant, working on the low-grade Western ores, using dry, wet and magnetic concentration. At De Pue, near Springfield, Ill., it is building a large spelter works and also an acid works, also using the Grillo-Schroeder process. (Concerning this contact process see our Vol. II., p. 347.) It has a smelting plant for the manufacture of high grade zinc oxide, used as a pigment, at Florence, Pa., where the oxide is made from burning metal or skimmings.

The plant at Palmerton is designed with the ultimate idea of making it the largest zinc plant in the world. The ores come from the famous Franklin furnace mine of New Jersey, where, by the Wetherill magnetic concentration process, the product from the wet concentrating mill is separated into willemite (the anhydrous silicate of zinc), and franklinite (the combined oxides of zinc, iron and manganese).

The Palmerton plant is situated in the anthracite coal district, and by an advantageous contract with nearby collieries the company is assured of a supply of anthracite coal for a long term of years. The plant consists of a spelter plant and zinc oxide plant, a large demonstrating Grillo-Schroeder sulphuric acid plant and a plant for making lithophon, the white enamel pigment made by the double precipitation of barium sulphate and zinc oxide and sulphide.

SPELTER WORKS.

The Palmerton plant is most substantially built, as the result of the combined metallurgical experience of all the plants of the New Jersey Zinc Co. The construction throughout is solid, brick, steel and reinforced concrete being everywhere used. The spelter works are designed for a future capacity of twelve furnaces of 200 retorts each. Ten of these furnaces will be of the type known as the Convers-De Saulles. This furnace uses the counter-current system of regeneration, the heat being transmitted from the products of combustion through special fire-brick to the flues in which the air for burning the producer gas comes up.

The producer gas coming from producers of the Taylor revolving-grate type, made by R. D. Wood & Co., of Philadelphia, and also from a new type of producer adopted by the company—the Hughes—is not preheated, but is delivered to the furnace at as high a temperature as is possible. The Hughes producer, made by the Wellman-Seaver-Morgan Co., Cleveland, Ohio, is of very solid and substantial construction. Its chief distinction is that the whole producer revolves. This enables mechanical poking and stirring of the anthracite slack to be employed and also insures a good distribution of the coal on the top of the producer.

A special apparatus of French design (the "Ados") mechanically records every 4 minutes the percentage of carbon dioxide in the producer gas. This the company's engineers have found to be most advantageous, for the reason that the workmen know that any neglect in operation of the producers is shown up at once by the automatic recording device.

Two other furnaces will be of the Siemens regenerative type. This type, as is well known, has a single arch spanning both sides of the furnace with the regenerators underneath the furnace; the gas sweeping from the bottom of one side of the furnace up through the four rows of retorts over the middle wall and down to the four rows of retorts on the other side, where it meets the regenerative bricks and gives its heat to the same bricks. The company's engineers state that at times the waste gases are lower than 150° C. in temperature.

As would be expected the Siemens type of furnace shows a better fuel economy than the Convers-De Saulles, for the reason that the absorption of heat is by direct contact on the regeneration bricks and not by conduction through 1.5 inch of fire-clay as in the Convers-De Saulles. But this advantage is more than neutralized by the fact that no reversals of gas and air are necessary in the Convers-De Saulles, and also that the temperature in the Convers-De Saulles is uniform, whereas in the Siemens there is a fluctuation of 150° C. in half an hour. This means that in the Siemens furnace there is a larger consumption of retorts, due to this sudden change of 150° C. every half hour, and also a larger consumption of condensers, for the reason that the change in temperature of the furnace is communicated to the gases of zinc and carbon monoxide that are produced in the reduction of the zinc ore, and that this change is manifested in a less degree in the condensers. Consequently there is a temperature change at the condensers, and checking, and cracking ensues.

The retorts are made in the Muehler hydraulic press out of a well-pugged clay. This clay is made of seven parts of St. Louis plastic clay for a binder and nine parts of crushed ground fire-brick for the cement or chamotte. The press is operated at as high a pressure as possible, from 1,500 to 2,000 pounds. The clay is pugged twice.

Mr. A. L. Queneau, a consulting engineer of the New Jersey Zinc Co., has patented an easy and simple means of making a composite retort with a lining of carborundum, chrome or bauxite, made from a composite cartridge which is made in

the stamp mill. This is patented, and the company anticipates making large-scale tests in one of their Western plants to investigate this process for the treatment of the iron-bearing ores of Leadville and the West.

The retorts or muffles are 7 inches x 9 inches inside and 48 or 60 inches long. The walls are 1¼ inches thick, and the butt is 1¾ inches thick. The average life of the retort is 28 days.

The charge consists of willemite analyzing from 48 to 50 per cent zinc, 7 to 10 per cent iron plus manganese, and 55 per cent of fine anthracite coal dust, used for reduction material. This anthracite analyzes from 79 to 81 per cent fixed carbon, and proves to be an ideal fuel for the zinc reduction purposes.

At present the retorts are charged by hand, but Mr. Queneau has invented and patented a mechanical charging device, consisting of a high-speed impeller, which makes a more uniform and better charging than can be done by hand charging. (See the department on Recent Metallurgical Patents in our present issue.) A large experimental machine has been built and operated, which machine has shown up certain advance in practical operation. A new machine is being designed taking advantage of this very valuable experience, and when once proven will be of great value to the company.

The charge is made much "heavier" than is the case in the Kansas practice. An average of 37 pounds of willemite per cubic foot of retort space is recommended by the company's metallurgists. The temperature of reduction of willemite is higher than that or roasted blende or calamine ores, and lies between 1,100° and 1,120° C. At the end of the operation the temperature inside the retort is as high as 1,450° C. The consumption of coal per ton of ore treated is quite high, from 1¾ to 2 tons per ton of ore.

The spelter produced at this plant is of extreme purity, analyzing 99.85 to 99.95 per cent zinc. This spelter is consumed for making the finest bronzes and for special zinc castings, spun brass work and cartridge cases, and also for the finest galvanizing, such as galvanized wire, and in general for all work where extreme ductility and tenacity are essential. At present only four furnaces are in operation. This spelter, sold as the famous "Horsehead brand," commands a price of from 3 cents to 4 cents above the market for "prime Western spelter."

Zinc Oxide Plant.

The zinc oxide plant is an immense affair. It has 408 Wetherill furnaces and several large bag-houses. The low-grade willemite and the magnetic heads, containing franklinite, are mixed with finely divided anthracite slack, and thrown on a bed of burning anthracite on the Wetherill grate. The gentle and uniform blast coming up through the perforations of the Wetherill grate burns the bed of anthracite below and reduces the zinc oxide in the ore to metallic zinc, which, of course, at the temperature is a vapor. This is burned under the arch of the Wetherill furnace to zinc oxide in the form of a very fine powder.

The products of combustion with the zinc oxide in suspension are led through a system of cooling pipes by the suction of electrically-operated water-cooled Sturtevant fans. Thence it goes to the bag-houses, where the zinc oxide is filtered out by the well-known system of filtration through cotton sheeting. Four long canvas bags discharge the zinc oxide into a hopper, whence it is collected in barrels and sold for zinc pigment.

There is now very little prejudice, if any, in the paint trade against zinc oxide as a paint. Indeed, it is believed that a mixture of white lead and zinc white produces the best pigment.

About 75 per cent of anthracite slack and a small percentage of limestone is charged with the zinc ore in the Wetherill grates. The ore averages about 20 per cent zinc. The residues average from 2 to 4 per cent zinc. A recovery of 85 per cent is considered fair work, while 90 per cent recovery is considered very good work.

The clinker from the Wetherill grates is drawn out by hand into chutes, and falls through these chutes into cars below. It is usually charged directly from these cars into the iron-blast furnace with additional limestone. This is a short blast furnace, 14 feet at the bosh, with 5-inch tuyeres, without any bosh plates, but instead cast iron segments cooled with a flow of water.

The iron and manganese in the clinker are converted into spiegeleisen. It is well up to Bessemer grade, analyzing 0.08 phosphorous (which phosphorous is principally from the coal and coke), or an iron-manganese alloy containing 20 per cent manganese; it is sold to steel makers for use in the converter or open-hearth furnace.

The fuel used in this blast furnace is large anthracite coal and Connelsville coke, in about equal proportions, though the tendency is to increase the percentage of coke. The blast of this furnace is heated in U-pipe stoves to about 500° C.; Le Chatellier pyrometers recording the temperature of this blast. It is the intention of the company to put in fire-brick stoves, but the difficulty in cleaning the secretions of zinc oxide from these stoves has prevented their use up to the present time. The company operates also two smaller spiegeleisen furnaces at South Bethlehem and Newark.

Some zinc oxide is collected in the furnaces from the burning of the gases in the U-pipe stoves. This oxide, called by the company spiegel oxide, is delivered to the spelter furnace and used to enrich the charge of zinc ore. This oxide is very easily reduced, and, in the parlance of the zinc man, "works very easy in the retort." Impure oxide from the Wetherill furnace, having been turned to oxide at the temperature of burning zinc or above 1,600° C., is on the contrary very hard to work in the retort, due to the fact that the combustion at a high temperature has produced a very strong union between the zinc and the oxygen, due to the violence of their combination. This, it may be remarked, is in line with the results found by W. McA. Johnson, published in our Vol. II., p. 185.

Perhaps one of the most striking features of the works in general is the consequence with which labor-saving devices are used throughout. Wherever possible the operation is automatic. The comparatively small number of workingmen which the visitors saw while being conducted through the very extended works, was indeed remarkable.

Electric motors are, of course, used everywhere. The direct-current two-wire system is employed, with a pressure of 240 volts. The power plant contains three 600-kw. generators, built by the Crocker-Wheeler Co. The visitors were shown through the plant by Major De Saulles, Mr. Stone, Mr. Queneau and other engineers of the New Jersey Zinc Co. Not the least pleasant part of the hospitality was the liquid refreshment, of purity equal to their famous "horsehead spelter," tendered to the visitors at the head office of the company. The acid plant and the lithophon plant were quite rightly kept secret, for several practical points of working in the same are better protected by secrecy than by patents. But this journal takes great pleasure in recording its sincere appreciation of the open kindness of the New Jersey Zinc Co.'s New York office in throwing open to the Institute the best spelter and zinc oxide plant in the world. Of course, it is hardly necessary to state that this fact was appreciated by all the visitors.

Visits to Cement Plants and the Thomas Iron Works.

In the afternoon visits were paid to the works of the Atlas Portland Cement Co., the Lehigh Portland Cement Co., and the Thomas Iron Co. The special train brought the party first to the plant of the Atlas Portland Cement Co., where lunch was served in the power house, which was very nicely decorated in honor of the Institute.

The visitors were then conducted to the different departments of the Atlas Portland Cement Co. and of the Lehigh

Portland Cement Co., and it was quite interesting to compare the difference in the equipment for carrying out the various stages of making cement in the two plants. At the Lehigh Cement Works the process of quarrying was also shown.

The excursion was concluded by a visit to the Thomas Iron Works, which was particularly appropriate in view of the fact that the projector of this company, Mr. David Thomas, had been the first president of the American Institute of Mining Engineers, being elected on May 16, 1871, at the Wilkesbarre meeting, and being the presiding officer at the Bethlehem meeting in August of that year, now almost thirty-five years ago. At these works the large blowing engines, installed in 1905 by the Allis-Chalmers Co., were of special interest.

Souvenirs were given to the visitors by these three companies in form of a diary from the Atlas Cement Co., a matchbox and a pen and pencil holder from the Lehigh Cement Co., and a paper weight in form of a little pig from the Thomas Iron Co.

In the evening there was an informal but most enjoyable reunion at the Northampton Club in South Bethlehem. For a happy change beer was served, and the refreshments were stated to be of the Pennsylvania Dutch type.

EXCURSION OF FEB. 24.

WORKS OF THE INGERSOLL-RAND CO. AND NEW JERSEY ZINC CO.

For the Saturday excursion a special train had been courteously provided by the Lehigh Valley Railroad. It left South Bethlehem at 9 o'clock, and took the party directly to the works of the Ingersoll-Rand Co., near Phillipsburg, N. J. The visitors were conducted by numerous guides through the works, where the manufacture of the company's well-known products were to be seen down to the smallest detail. The whole plant was thrown open to the party and the drills and compressors were to be seen in all stages of manufacture. Many were also shown in operation.

At the close of the inspection the party was taken to the company's private dining rooms, where a six-course dinner with wine and champagne was served. The whole party was in the best of humor, which found its expression in several after-dinner speeches, Major De Saulles acting as toast master.

For the photograph which is reproduced on page 87, and which was taken at the front of the Ingersoll-Rand Co.'s plant, we are indebted to that company.

The party was then taken back to South Bethlehem, where they were conducted through the plant of the New Jersey Zinc Co., which has already been described in our Vol. III., p. 380. This was the official conclusion of the ninetieth meeting of the Institute, which will long be remembered with pleasure by all who had the privilege of attending it.

The following is a complete alphabetical list of the members and guests who registered at the meeting:

E. O. C. Acker, Bethlehem, Pa.; William Afflich, Ellsworth, Pa.; Edgar A. Ashcroft, London, Eng.; W. S. Ayres and Mrs. Ayres, Hazelton, Pa.; F. E. Bachman and Mrs. Bachman, Port Henry, N. Y.; H. Foster Bain, Urbana, Ill.; Samuel Baker, Philadelphia, Pa.; Robert M. Bird, South Bethlehem, Pa.; Cyrus Borgner, Mrs. Borgner and Miss Borgner, Philadelphia, Pa.; Horace Boyd, Hokendauqua, Pa.; John Boyer, Bethlehem, Pa.; Albert Brodhead, Bethlehem, Pa.; Otto C. Burkhart, Bethlehem, Pa.; Robert E. Brooke, Birdsboro, Pa.; R. C. Carpenter, Ithaca, N. Y.; S. P. Christie and Mrs. Christie, High Bridge, N. J.; William H. Chandler, South Bethlehem, Pa.; F. H. Clyner, Reading, Pa.; E. T. Clymer, Philadelphia, Pa.; Lee S. Clymer and Mrs. Clymer, Riegelsville, Pa.; W. B. Cogswell and Mrs. Cogswell, Syracuse, N. Y.; Frederick Conlin, Bethlehem, Pa.; Geo. G. Converse, South Bethlehem, Pa.; Edgar B. Cook, Pottstown, Pa.; Edgar S. Cook and Mrs. Cook, Pottstown, Pa.; C. B. Cook, Pottstown, Pa.; M. R. Cutter, Bethlehem, Pa.; Arthur B. DeSaullee, South Bethlehem, Pa.; W. A. Doble, San Francisco, Cal.; Chas. M. Dodson, Bethlehem, Pa.; P. J. Donohue, Salt Lake City, Utah; B. I. Drake, New York City; Henry S. Drinker and Mrs. Drinker, South Bethlehem, Pa.; Mr. Dunn, Easton, Pa.; Howard Eckfeldt and Mrs. Eckfeldt, South Bethlehem, Pa.; Geo. R. Elder, South Bethlehem, Pa.; Lincoln Ellsworth, Ellsworth, Pa.; Wm. Esty, Bethlehem, Pa.; Ernst F. Eurich, Montclair, N. J.; Harold G. Eynon, Bethlehem, Pa.; Thomas M. Eynon, Philadelphia, Pa.; B. F. Fackenthal, Jr., and Mrs. Fackenthal, Riegelsville, Pa.; Mrs. B. F. Fackenthal, Hokendauqua, Pa.; A. B. Fichter, Bethlehem, Pa.; F. Firmstone, Easton, Pa.; W. S. Franklin, Bethlehem, Pa.; John Fritz, Bethlehem, Pa.; T. W. Fuller, Jr., and Mrs. Fuller, Catasauqua, Pa.; E. W. Furst, Cleveland, Ohio; James Gayley, New York City; Fritz Glein, Portoferrais, Italy; G. McM. Godley, New York City; H. H. Godshall, Lansdale, Pa.; Chas. Goodman, New York City; R. W. Gordon, Rhyolete, Nevada; Chas. B. Green, Easton, Pa.; N. V. Hansell, Lyon Mountain, N. Y.; Edward Hart, Easton, Pa.; C. W. Hayes, Washington, D. C.; F. R. Hayes, Fairmount, W. Va.; J. E. Haverstick, Philadelphia, Pa.; Homer W. Hendricke, Bethlehem, Pa.; Hendry H. Henshaw, Albany, N. Y.; H. V. Hesse, Fairmount, W. Va.; L. Holbrook and Mrs. Holbrook, New York City; Garrett L. Hoppes, Bethlehem, Pa.; J. C. Holderness, South Bethlehem, Pa.; Henry M. Howe, New York City; G. A. Howells, New York City; Chas. E. Hulick, Hellertown, Pa.; C. S. Hurd, New York City; Edward S. Hutchinson and Mrs. Hutchinson, Newtown, Pa.; W. R. Ingalls, New York City; John D. Irving, South Bethlehem, Pa.; W. I. Johnson and Mrs. W. I. Johnson, New York City; W. McA. Johnson, New York City; Archibald Johnston, Bethlehem, Pa.; J. H. Jewett, New York City; Edward K. Judd, New York City; J. F. Kemp, New York City; Paul S. King, New York City; C. Kirchhoff, New York City; Joseph F. Klain, Bethlehem, Pa.; I. N. Knapp, Philadelphia, Pa.; S. F. Knapp, Cleveland, Ohio; Walter S. Landis, Bethlehem, Pa.; I. H. Lee and Mrs. Lee, Baltimore, Md.; N. Lilienberg, Philadelphia, Pa.; Stuart Lindeley and Mrs. Lindeley, Orange, N. J.; Garrett B. Lindermen, South Bethlehem, Pa.; C. P. Linville, State College, Pa.; I. P. Löhne, Cleveland, Ohio; E. J. McCausland, Ithaca, N. Y.; E. M. McIlvain and Mrs. McIlvain, South Bethlehem, Pa.; Wm. R. McIlvain and Mrs. McIlvain, Reading, Pa.; Henry Maddock, Bethlehem, Pa.; Chas. A. Matcham, Mrs. Matcham and Miss C. Matcham, Allentown, Pa.; Mr. Sydney H. Matcham, Allentown, Pa.; C. A. Meissner, New York City; Mansfield Merriman, South Bethlehem, Pa.; Harlan C. Miner, Gloucester, N. J.; H. S. Munroe, New York City; R. O. Norris, Wilkesbarre, Pa.; C. L. O'Neil, Allentown, Pa.; George Ormrod, Mrs. Ormrod and Miss Ormrod, Allentown, Pa.; I. P. Pardee and Mrs. Pardee, Hazelton, Pa.; E. W. Parker, Washington, D. C.; G. S. Patterson and Mrs. Patterson, Vivian, W. Va.; Edmund C. Pechin, Buchanan, Va.; George Pettinos, Bethlehem, Pa.; Jos. S. Pendleton, Reading, Pa.; A. L. J. Queneau, South Bethlehem, Pa.; Rossiter W. Raymond, New York City; Thomas T. Read, New York City; Thomas Robins, Jr., New York City; M. K. Rodgers, Seattle, Wash.; E. F. Roeber, New York City; C. W. Roepper, Boston, Mass.; Jos. W. Richards and Mrs. Richards, Bethlehem, Pa.; Robert H. Richards, Boston, Mass.; John F. Saeger, Allentown, Pa.; James F. Sanborn, New York City; Robert H. Sayre, South Bethlehem, Pa.; Harry J. Seaman and Mrs. Seaman, Catasauqua, Pa.; Edward Schroeder, New York City; Abraham S. Schropp, Bethlehem, Pa.; J. M. Sherrerd and Mrs. Sherrerd, Easton, Pa.; F. F. Sharpless, New York City; P. W. Shimer, Easton, Pa.; E. M. Shipps, Newburgh, N. Y.; E. Bennett Smith, Wilkesbarre, Pa.; Oberlin Smith, Mrs. Smith and Miss Smith, Bridgeton, N. J.; Baird Snyder, Jr., Lansford, Pa.; Morton Stevens, Philadelphia, Pa.; Joseph Struthers, New York City; H. H. Stock, Scranton, Pa.; L. S. Sullivan, Bethlehem, Pa.; Knox Taylor and Mrs. Taylor, Plainfield, N. J.; L. H. Taylor, Jr., Philadelphia, Pa.; John M. Thomas, Island Park, Pa.; J. B. Tyrrell, Dawson, Y. T.; R. S. Weaver, Catasauqua, Pa.; Walter Harvey Weed and Mrs. Weed, Washington, D. C.; Olaf Wenstrom, Boston, Mass.; Maunsel White, Bethlehem, Pa.; E. P. Wilbur, South Bethlehem, Pa.; W. A. Wilbur, South Bethlehem, Pa.; Eldridge Wilbur, South Bethlehem, Pa.; John F. Wilcox, Orange, N. J.; William S. Wintersteen, Bethlehem, Pa.

The Use of Chlorine Gas Under Moderate Pressures in the Chemical Arts.

BY EDGAR A. ASHCROFT.

The tendency of the present day in electrochemical arts is all towards the cheaper and cheaper production of chlorine. This is largely due to the introduction of electrolytic caustic processes. The markets for bleaching powder have not kept pace with this development, and a modern branch of electrochemical industry, the direct electrolytic manufacture of chlorates, has also shut the door of outlet for chlorine gas long open in that direction.

Therefore, chlorine gas, once a main end-product of the alkali industry, only to be reached after an expensive and complicated chain of operations, is to-day a mere by-product. It is, however, a by-product which cannot, on account of its offensive properties, be thrown entirely away, and, therefore, great inducements are offered to the chemical engineer to find fresh outlets for this product. As a result many works are seeking such an outlet by manufacturing a number of chlorine

derivatives, amongst which may be named carbon-tetrachloride, stannous chloride, zinc chloride, sulphur chloride, etc.

Many of the operations necessary for the production of such products are greatly facilitated if the gas can be bubbled through a liquid (in some cases a fused solid) substance, and so supplied under a moderate pressure sufficient to overcome the pressure head represented by a column of a few feet of the material under treatment.

For this purpose ordinary fans (ebonite coated or other-

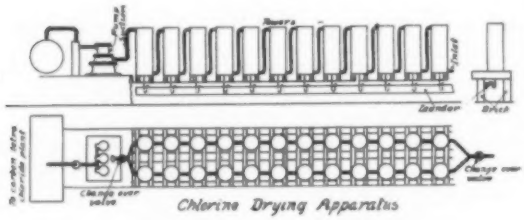


FIG. 1.—SECTIONAL VIEWS OF CHLORINE DRYING APPARATUS.

wise) are of no service, as by no practical device (such as multiple-series) can enough pressure be obtained.

Some years ago the writer had occasion to meet the above requirements in connection with some work for the Phœnix process for the production and electrolysis of zinc chloride from sulphide ores. Some account of the system he then worked out will possibly be found of interest to those engaged in finding outlets for chlorine gas.

This system is based upon the discovery that chlorine and hydrochloric acid gases at ordinary temperatures, *if perfectly free from moisture*, do not attack any of the ordinary metals. It is, therefore, *quite* practicable to pump the gas to *any* pressure by ordinary pumps, if certain precautions are taken.

That such a system is inherently possible is clearly evident when a few experiments are made with dried gas. The direct chlorine reactions, such as

$$Fe + Cl_2 = Fe\,Cl_2$$

like the allied oxygen reactions seldom, if ever, occur below a temperature of several hundred degrees centigrade. Even such active metals as melted zinc or metallic sodium below their critical temperatures of reaction are scarcely at all attacked by dry chlorine or oxygen (as is usually supposed), whilst good, even grained iron or steel working as valve faces to valves of ordinary engineers' bronze are absolutely unaffected by the gas for long periods.

The source of all corrosion, therefore, with chlorine gas at ordinary temperatures is found in the secondary reactions, due to the formation of HClaq. This will take place either from moisture introduced with the gas, with air leaking in, or with the oil used to lubricate the pumps. Many complicated reactions also take place with the latter, which necessitates in practice special precautions. This then is the whole theory of the subject and the rest is merely a matter of mechanical design and practical experience.

The writer did a great deal of work with different kinds of fans, pressure blowers, cascade pumps, and even had a Parsons turbine air compressor constructed specially for this purpose, but all these means were found defective in one or other particular, and he finally found the best solution of the problem to be in the use of ordinary metal reciprocating pumps, with displacement plungers and oil seals, using a special kind of oil for lubricating and for the seals which prevent the escape of gas into the air.

The main principles to be borne in mind are summarized thus:

1. The gas (and all associated air) must be carefully dried by desiccation, and, after drying, great care must be taken that no moisture-bearing air leaks into the pumps or apparatus through suction glands, etc. Directions for desiccating the gas on a large scale are given below.

2. Owing to the pungent and corrosive properties of chlorine in ordinary moist air, leaks of even minute traces, such as would be negligible in pumping air, or even ammonia, are to be avoided, and, therefore, a certain specific design of pumps, with oil seals, etc., as shown in Figs. 4, 5 and 6 and described below, is requisite.

4. All ordinary kinds of oil being acted on by chlorine gas, a special oil is necessary, both for oil seals and for lubricating the pumps. The preparation of this oil, which is the result of empirical experiment, is described below.

5. It is to be observed that the rise of temperature of chlorine gas under compression, being much greater than that of air, it is necessary to use more stages to reach a given pressure, and it is generally also preferable to run the pumps slower for similar reasons. By observing these principles any desired pressure can be obtained successfully. It is thus quite practicable to manufacture liquid chlorine by this system. At present, however, we are only contemplating producing a maximum pressure of 20 pounds per square inch, which gives the pressure usually required for actual work and a margin of stored gas for flexibility. This can be successfully accomplished in a single stage. Anything beyond this can be met by any ordinary chemical engineer, who will apply the above principles to the existing practice for other gaseous compounds.

The whole apparatus employed by the writer is illustrated in

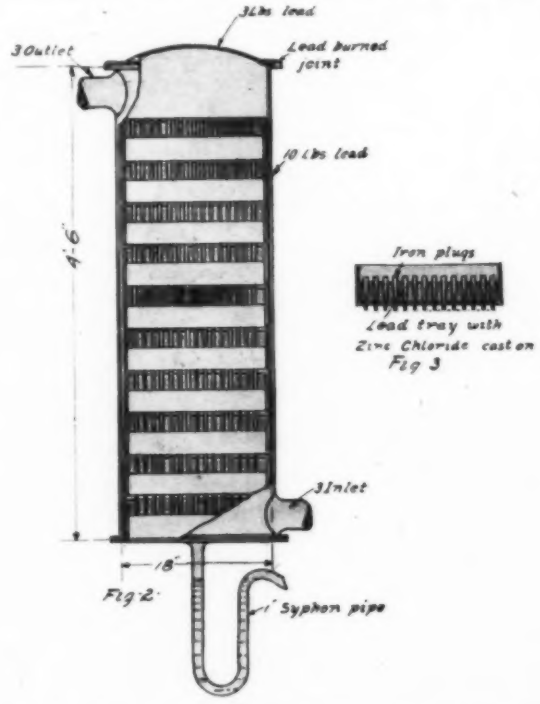


FIG. 2.—SECTION OF LEAD-DRYING TOWER. FIG. 3.—LEAD TRAY WITH ZINC CHLORIDE CAST ON.

Fig. 1. There is a receiver which may conveniently consist of an old boiler or air receiver, having a good margin of safety, This is carefully tested and made tight in all joints and tarred inside and out. All useless joints should be eliminated, and all *necessary* joints made good and strong on a uniform plan, consisting of jointing by plain sheet lead, without any cement, between *strong* metal flanges. All valves should be of close-grained iron or steel bodies and seats, and have gunmetal (bronze) spindles and valves, with strong threads and good (asbestos-packed) glands. Always arrange the valve so that

the *permanent* pressure does not come on the gland and packing, as the latter is apt to leak and need repacking, which then can be done during temporary closure of the valve. Otherwise, the shutting down and removal of gas from the entire system becomes necessary; and as this in practice will be naturally avoided as long as possible a slight leak under such adverse conditions is apt to develop into a chronic nuisance.

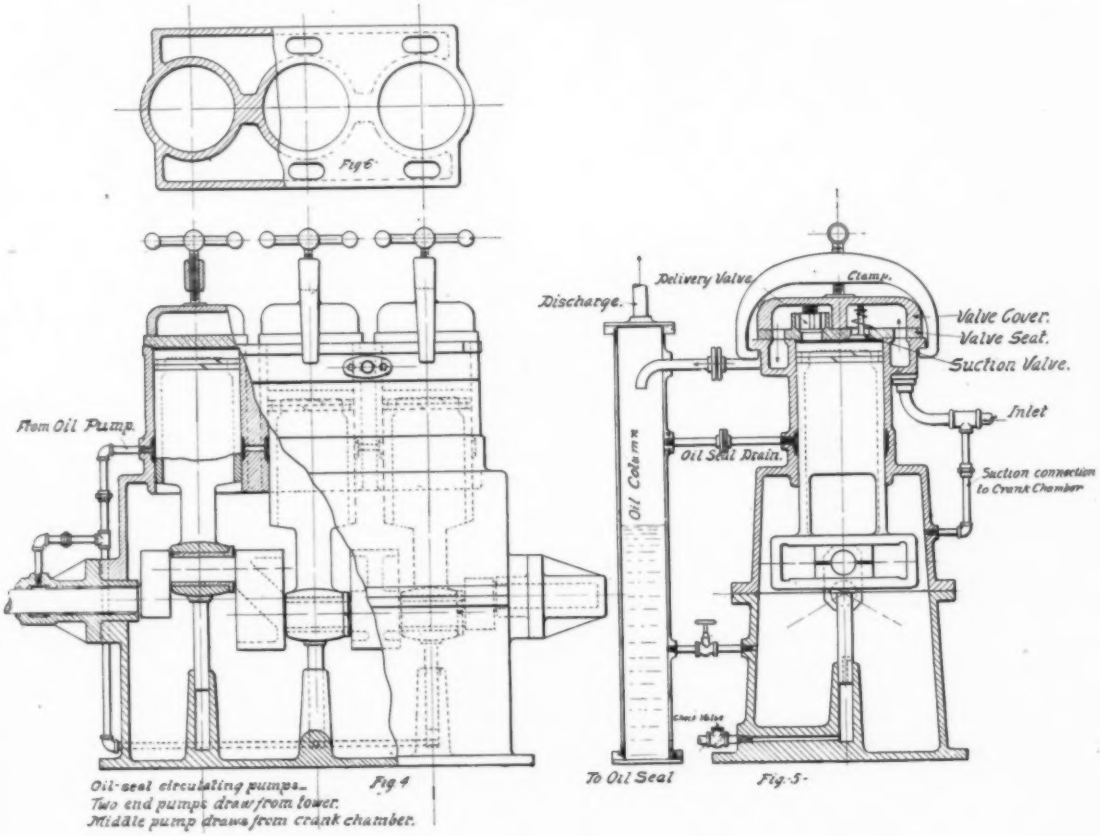
This receiver is filled direct from the pumps through the standing oil column. The same remarks as above apply to all pipes, joints and valves on the pressure side. The details of this pump are further described below and illustrated in Figs. 4, 5 and 6.

On the suction side of the pumps all pipes may be most readily made of lead, with burned joints, and the same material has been found suitable for the drying towers.

(N. B.—It will be found advisable when very permanent work is contemplated to substitute special earthenware for lead in these towers and pipes; but the writer has used lead apparatus for several years of continuous work without difficulties arising.)

Figs. 2 and 3 illustrate a single drying tower. The desiccating medium found most useful is zinc chloride, all of which is recovered in the form of a strong solution running from the drain pipes and is periodically recast into the trays, as shown after concentration and expulsion of the moisture gathered. This is very easily and cheaply accomplished by evaporating and fusing the zinc chloride in an enamelled iron pan and casting while still fused into the trays, inverted for the purpose. During concentration the material passes through a "frothing stage," which, however, is not troublesome when working in an open pan. After this stage is passed the material settles down into quiet fusion at a temperature which need not exceed 350° C.

The packing of the towers in practice only requires to be done about once in three months, unless the gas is very wet. The lead top is removed for this purpose and the trays taken out and refilled, the trays being inverted and plugs inserted in the holes whilst casting the chloride in, after which the trays are replaced and the lead top is again burned into place. These operations do not cut any big figure in costs. It has been found most convenient to use twenty-four such small towers, connected in two series of twelve each, and arranged with change-over lute valves, so that either series can be isolated at will for repacking. The connecting pipes through-



FIGS. 4, 5, 6.—STURGESS TRIPLEX PUMP, ADAPTED FOR PUMPING DESICCATED CHLORINE BY THE ASHCROFT SYSTEM.

out this series may be of 3-inch diameter. The "suction head," due to the friction of the towers and pipes will then be about 6 inches of water when pumping 40 cubic feet per minute in the apparatus illustrated.

Owing to the very considerable volume of mingled air always present with the gas leaving the electrolytic cell, due to the practical impossibility of completely sealing such apparatus, experimental data of actual conditions should be obtained for each plant and the apparatus proportioned accordingly. When hot gases are to be pumped this dilution of the gas by cooler air will be an advantage. In that case the first towers and pipes must be of more refractory material than lead, but the gas easily and rapidly cools to the temperature of the surrounding air in passing through the system of towers. In case of pure and very hot gases, a cooling device could be readily devised to eliminate this difficulty.

The special oil for the pumps, which plays rather an important part in this system, is prepared as follows:

Good sperm whale oil is treated with a jet of chlorine, the gas being bubbled through a cask of oil until no more chemical action (indicated by the rise in temperature of the oil) occurs. The oil will then be found to be strongly acid, and this must be neutralized by the addition of fine white zinc oxide, which is stirred well in and allowed to settle. After pouring off, the clear oil is found to be "chlorine proof," and it is the *only* oil in the writer's experience which is really satisfactory, although many lubricants only slightly affected by chlorine, such as glycerine, are partially satisfactory.

(N. B.—It has been suggested to use as a pump lubricant and in the seals, in place of this oil, strong oil of vitrol, which also has no action on ordinary metals at ordinary temperatures, and probably this would answer and might be cheaper; but so far it has not been tried. The fact that it is strongly hygroscopic is also against it, as in the case of glycerine.)

The special features of the pumps remain to be described. Figs. 4 and 5 illustrate in section a modified form of Sturgess air and oil pump, which fulfills all the necessary conditions admirably. The special features of this pump are: (1) Simplicity of design, eliminating all fancy work; (2) ease of access to valves; (3) complete enclosure of all working parts and the connection of the crank chamber to the main suction system, in order to take up any possible escape of gas; (4) a system of oil circulation and oil seals by means of which the double object of perfect lubrication and complete avoidance of leaks either outward or inward is obtained. The rest of the pump and apparatus will explain itself from a study of the drawing herewith—Figs. 4, 5 and 6.

It will thus be seen that there is nothing strikingly new or remarkable about this system of pumping chlorine; but the elaboration of small details, which have made it a practical success, will not be without interest and importance to those requiring to do similar work. Such matters of detail often take a considerable amount of experiment, involving both time and expense before they are overcome in practice.

The Zinc Industry in the Year 1905

By Franz Meyer, Ph. D.

The year 1904 was not a favorable one for the zinc smelting industry in this country. If we take the price for 60 per cent Joplin concentrates and the New York quotation for spelter as a basis, the ore price advanced about $3.00 per ton in 1904, while the price for spelter dropped 0.3 cents per pound during the same period, as compared with 1903, so that the smelters who, during the last decade paid about 50 per cent of the New York spelter price for the zinc in the ore, had, in 1904, to purchase their ore at a price of over 61 per cent of the spelter price.

These conditions have become still worse during the year 1905, as the price of Joplin ore has advanced about $10.00 per ton as compared with the previous year, while the increase in the spelter price was only 0.8 cents per pound, so that during the last year the smelters have paid almost 67 per cent of the New York spelter price for the zinc in the ore.

The situation in 1905 was, therefore, far from being satisfactory for the smelters, and an unduly large proportion of the high price for spelter which prevailed during the last year has gone to the miners of zinc ores, as will be seen from the following Table I, which was compiled from the *Mineral Industry* and the *Engineering and Mining Journal*, for the purpose of showing the relation between the price of 1 pound of zinc in the ore and in the spelter during the last ten years.

Table I. shows at a glance that the year 1905 has been the most unfavorable for the zinc smelting industry in this country during the last decade, and that the demand of the miners for a duty on zinc ores is not justified, as such a duty would have the effect of still aggravating the unprofitable conditions under which the zinc smelters have had to labor for the past two years.

The European zinc smelters have received a fair share of the high prices for spelter which also abroad governed during the last year, due to the fact that in Europe zinc ores are bought on a sliding scale, based on the London quotations for spelter. Such a system of price-making is fair to the miner as well as to the smelter, and there is no reason why it should not be adopted in the United States, more so, as in the lead and copper

TABLE I.

Year.	Average Price of 1 Ton 60% Joplin Con.	Average Price of 1 lb. Zinc in the Ore.	Average Price of 1 lb. Spelter in New York.	Difference between the two Prices.	Cost of 1 lb. Zinc in the Ore in per cents of the cost of 1 lb. Zinc in the Spelter.
1896.....	$22.33	1.80c.	3.94c.	2.08	47.2%
1897.....	22.28	1.86	4.12	2.26	45.2
1898.....	28.44	2.37	4.57	2.20	51.9
1899.....	38.54	3.21	5.75	2.54	55.8
1900.....	26.50	2.21	4.39	2.18	50.1
1901.....	24.21	2.02	4.07	2.05	49.7
1902.....	30.73	2.56	4.84	2.28	52.9
1903.....	34.44	2.87	5.40	2.53	53.1
1904.....	37.58	3.13	5.10	1.97	61.4
1905.....	47.00	3.92	5.88	1.96	66.7

smelting industry of this country the ore contracts are already based on the prices for lead, copper and silver which prevailed during the month, in which the ores were delivered to the smelters.

Ores.

Due to the conditions in the Joplin ore market, the zinc smelters have during the last year treated still larger quantities of low-grade ores than in previous years. The main supply of these ores comes from Colorado, New and Old Mexico, and British Columbia, where, before long, a zinc smelter will be in operation. There has also been an increase in the production of high-grade concentrates in Wisconsin, and there is every prospect that this State will become an important competitor to Missouri in the production of high-grade blende concentrates, as great activity is noted throughout the zinc-producing district in Southwest Wisconsin, both in the prospecting for and the development of new deposits and in the construction of mills.

As the Wisconsin blende is not magnetic, the product from the wet separation, containing the zinc sulphide besides pyrites and markasite, must be partially roasted to render the iron sulphides magnetic, before it is subjected to magnetic separation. For this reason the Wetherill magnetic separator has found no application in this field, the less expensive magnetic separators designed for the treatment of highly magnetic materials being used. In Colorado, however, where the blende is weakly magnetic, the Wetherill is still the leading machine for the production of zinc concentrates without preliminary roasting, and also with British Columbian ores it has given good results.

A mill equipped with Blake-Morscher electrostatic separators was put into commission during 1905 in Salt Lake City, Utah, where it is said to do good work with ores from Park City, Utah. Of the floating processes which have been successfully introduced in Australia, none has found application in this country as far as is known.

Roasting.

Of the mechanically-stirred muffle furnaces, the Hegeler kiln is still the only one which is used in actual practice in the United States. The two new zinc works now in the course of construction, namely, those of the Mineral Point Zinc Co., at De Pue, Ill., and the plant of Messrs. Hegeler Bros., at Danville, Ill., will also use this type of kiln. At the first-named works the gases from the roasters will be utilized for the manufacture of sulphuric acid by the Schroeder contact process, while at the latter plant the chamber process will probably be used for this purpose. In this connection it may be mentioned that the General Chemical Co., who own the Her-

reshoff & Ferguson patents for the manufacture of sulphuric acid by catalysis, have recently acquired the exclusive United States rights for the use of the contact patents of the Badische Anilin & Soda-Fabrik, at Ludwigshafen, and of the Farbwerke, vormals Meister, Lucius & Bruening, at Hoechst, Germany, so that it may be expected that before long one of these processes, which are in operation on such an extensive scale in Europe, will also be applied to the manufacture of sulphuric acid from blende roasting gases in this country.

For improvements in mechanically-stirred muffle furnaces of the McDougal type, a number of patents have been granted during the last year, of which the following ones may be mentioned:

In A. R. Meyer's United States patents Nos. 780,115, 804,751 and 804,752, improvements in the construction of the shaft and rabble arms of the furnaces protected by United States patent No. 750,877, and means for cooling these parts of the furnace, are claimed. The designs as described in the above patents are rather complicated and expensive. In his United States patent No. 800,588, the same inventor proposes to reduce the high fuel consumption, due to the short passage to which the gases of combustion are compelled, in a muffled McDougal kiln, by a construction which very closely resembles the roasting furnace protected by F. Meyer's United States patents Nos. 731,114 and 761,691. The only difference between the two kilns lies in the fact, that in A. R. Meyer's design the walls separating the ore beds of the units arranged in a block from each other do not extend all the way up. This is no improvement on F. Meyer's construction, as for the replacement of a rabble arm and for other repairs in A. R. Meyer's furnace the whole block must be shut down, while in F. Meyer's design only a single unit is out of commission during repair work.

It is also more than doubtful whether A. R. Meyer's patent can be sustained in the courts, as it makes use of F. Meyer's prior invention to heat a muffle roasting furnace, consisting of a plurality of vertical chambers, each made up of a series of superposed hearths discharging from one to the other, and having rotary stirrers mounted upon a vertical shaft by a heating furnace common to the series.

W. R. Ingalls, in his United States patent 786,567, prolongs the course of the flames by placing a radial partially in the annular flue underneath the hearths of a McDougal kiln to be heated, whereby the fuel gas is compelled to make a circuit around the central partition protecting the shaft. He also proposes to convey the air by which the shaft and rabble arms are cooled, and which air is thereby preheated, to the lowest muffle, where the most extraneous heat must be supplied.

The same idea of transferring heat from parts where an excess may be generated to a point where all available heat is required, has been described by F. J. Falding in his United States patent 756,485.

In the United States patent 785,437, which was assigned to Frank Klepetko, who as the first one built the McDougal klins with a large diameter, now used so extensively in Montana and Utah for the roasting of cupriferous pyrites, C. H. Repath and F. E. Marcy show a furnace of this type with seven hearths, of which the two lower ones are heated directly, to effect the secondary roasting, which splits up the basic sulphates that are formed on the upper hearths. The gases from these two lower hearths are mixed with fuel gases and are, consequently, not suited for the manufacture of sulphuric acid, while the gases generated on the five upper hearths can be utilized for this purpose. To avoid the formation of large quantities of flue dust, the invention also embraces slides, over which the ore descends from one hearth to the next hearth below in a continuous stream. There is no doubt that in this kiln, the lower two hearths of which are operated like a reverberatory furnace, the fuel consumption will be lower than in kilns of the same type, of which the lower hearths are muffled. On the other hand, in furnaces of the latter description the whole of the gas developed can be utilized for the manufacture of sulphuric acid, besides the metallic losses are smaller in muffle kilns than in those of the reverberatory type.

F. J. Falding, in his United States patent 788,098, claims some improvements on the O'Brien furnace which belongs to the McDougal type. This furnace has been muffled, and will soon be tried by the United Coke & Gas Construction Co., who build it. If properly designed the kiln will, no doubt, roast blende down to a low percentage of sulphur, but the fuel consumption will be high, on account of the short passage of the heating gases.

A roasting furnace designed on a principle quite different from that underlying the above constructions is described by A. W. Chase in his United States patent 804,379. This kiln consists of a series of superposed screw conveyors, the trough of which is made from refractory clay, while the screw is built up from cast-iron wings and a drawn steel tube, which can be cooled by water. This kiln was tried as a reverberatory for pyrites and as a muffled furnace on blende, but in both cases the experiments have not led to its introduction.

SMELTING.

No inventions of a revolutionizing character have been made during 1905 in the reduction of zinc ores. Of the improvements of minor importance the introduction of the Mehler hydraulic retort press in two works in the Kansas gas field and at one smelter in Virginia may be mentioned. The use of hydraulic-made retorts, which stand the corrosive action of ferruginous ores much better than the old-fashioned retorts, on account of their greater density, has enabled the zinc smelters to utilize large quantities of low-grade ores. While a few years ago blende with more than 2 per cent iron was regarded as almost unfit for the manufacture of spelter by the United States smelters, they have now, like their European brethren, learned to treat ores with as high as 20 per cent iron.

The experiments with the Lungwitz process at Warren, N. H., which I mentioned in my last year's report, have not led to a result, because of certain mechanical shortcomings in the construction of the furnace, which were only detected during the operation. These mechanical difficulties are, however, not unsurmountable, and the experiments, it is said, will be continued this year.

An editorial in this journal (Nov., 1905) and A. Lodin, in his recently published book, *La Metallurgie du Zinc*, draw attention to the fact that according to the law of the partial gas pressure the furnace must be placed under a considerably higher pressure than the inventor contemplates to use, in order to increase the pressure on the comparatively small volume of zinc vapor present in the mixture of the gases in the furnace to raise its boiling point sufficiently.

The experiments which were conducted in Hamborn-on-the-Rhine with O. Nagel's process, described in his United States patent 766,279, have been abandoned, according to information from the inventor, before conclusive results as to the merits of the process were reached.

P. Schurieder's shaft furnace, protected by United States patent 757,059, and also referred to in my last reports, is now being tried in Upper Silesia, Germany; the results have, however, not yet been made known.

F. Kellermann, in *Mining Magazine*, Vol. XII., 4, p. 310, recommends to arrange a series of his furnaces, which may be considered as vertical retorts, around one gas producer as heating source common to the whole series. According to his opinion, shaft furnaces heated internally promise very little success, as the dilution of the zinc vapors with inert and even oxidizing gases is too large to allow their condensation. Kellermann figures that in a zinc retort the proportion of the volumes of zinc vapor and carbon monoxide is about 1 to 2, while in an internally heated shaft furnace this relation is 1 to 19.

Armstrong, in his British patent 20,543, 1904, shows an improved form of the furnace described in his D. R. patent

132,139, and mentioned in my last year's report. As far as is known none of these constructions has been tried in practice.

Of the patents granted on improvements in the old-type retort furnace, the following may be mentioned:

H. and J. W. Hegeler, in their United States patent 792,773, in which a regenerative furnace with chambers for preheating both air and gas is shown, propose to introduce the entire amount of the air at the bottom of the retort chamber under the lower tier of retorts, and to have an excess of air up to the top of the combustion chamber and to introduce the producer gas at various heights of the chamber through channels in the center wall. If the size of the gas openings can be regulated with sufficient exactness, the arrangement will warrant great uniformity in heating the retorts, but the regulation of the numerous gas exits will be a very difficult, if not impossible, task.

E. C. Hegeler, in his United States patent 794,799, describes the long furnace as used by the Mathiessen & Hegeler Zinc Co., in La Salle, Ill. The waste heat from this furnace, which is very simple and inexpensive as compared with the Siemens regenerative furnace, is not utilized for preheating the gas or air, but it is made use of for generating steam in a set of boilers placed near the one short end of the furnace, the same as is done so successfully now with the waste heat from the long reverberatory copper smelting furnaces.

Although P. A. Mackay's United States patent 799,743 does not strictly refer to the smelting of zinc ores, it may be mentioned in this connection, as it has for its object the removal of cadmium from calcines containing same preparatory to their smelting. For this purpose the inventor leaches the calcines, which contain the cadmium in form of water-soluble $CdSO_4$, while all other oxides and sulphates formed in roasting are practically insoluble in water. This patent is of no great practical value, as a trace of cadmium in the spelter is in most cases not objectionable. Even the spelter used for brass making may contain up to 0.5 per cent Co. Where the spelter is used for the manufacture of zinc oxide it should, of course, be free from cadmium, as its oxide is brown, and these discolor the zinc oxide. In this country, however, very little zinc oxide is made from spelter.

Of the electrolytic processes for the recovery of zinc from its solution, A. G. Betts' United States patent 791,401 may be briefly described. Betts proposes to leach ores with sulphuric acid, to electrolyze the solution with an insoluble anode and with a liquor metal cathode, for which he prefers to use mercury either pure or with zinc. The zinc-mercury-alloy formed, and which contains less than 5 per cent zinc, is removed to another cell, containing a solution of zinc chloride, into which a zinc cathode is introduced, the zinc-mercury-alloy forming the anode. The zinc dissolved from the alloy is deposited on the cathode. After the removal of a large part of the zinc the mercury is used over in the first cell. The process is rather complicated, and as losses of mercury, which is so much more expensive than zinc, cannot be entirely avoided, it is very doubtful whether zinc can be made economically by this method.

The same must be said about the process which O. W. Brown and W. F. Oesterle describe in Electrochemical and Metallurgical Industry, Vol. III., p. 378. These authors propose to smelt a mixture of zinc sulphide, calcium oxide and coal in an electric resistance furnace. The results obtained with certain proportions of this mixture and described in the above publication are not very encouraging.

Conclusion.

Although the great number of patents taken out during the last year indicate that many efforts have been made during the last year to improve the present expensive method of recovering zinc from its ores, not much has been accomplished in this direction during 1905. It is, therefore, still true, as I stated in winding up my last year's report, that the zinc industry offers still many opportunities to an inventive mind.

Two Tests of Electrolytic Hypochlorite Plants in England.

By W. Pollard Digby.

Engineering interests being liable to run in cycles—superheated steam, for instance, is not the discovery of the last decade or so—and interest having recently been rearoused in regard to the properties of electrolytically-produced hypochlorites of soda, magnesium, etc., by means of some experiments at Guildford last year, together with some trials in the North of England in regard to the bleaching of paper pulps, and the fact that a London Borough Council is contemplating the erection of a municipal electrolizer, the writer has thought it opportune to describe a record of a test taken some six years ago, together with a record of a more recent test of a similar plant.

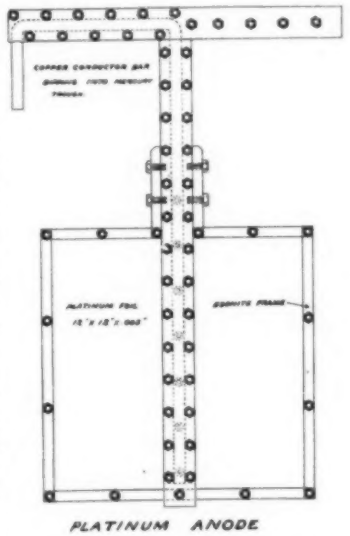


FIG. 1.—ELECTRODE CONSTRUCTION.

The first test was taken at Maidenhead, where, at the local sewage outfall, the effluents were being sterilized by the "electrozone process." As at first used in this country Woolf's form of electrolizer was employed: the anodes consisting of platinum foil and the cathodes of carbon or zinc, but subsequently the Crawford modification was employed (British patent No. 14,852, of 1896). The construction of the anodes was slightly altered from the Woolf pattern; it is shown in Fig. 1.

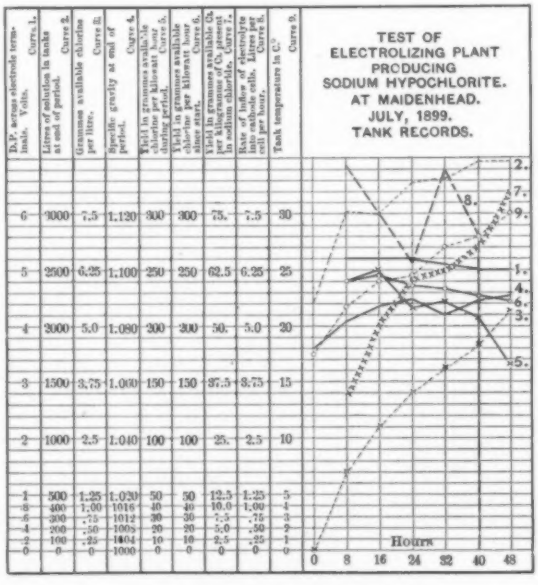


FIG. 2.—TEST OF HYPOCHLORITE PLANT.

The essential features of the Crawford patent, as applied to

the manufacture of hypochlorite solutions, lay, firstly, in the use of air agitation, which maintained a circulation of the electrolyte, and also served to keep down the temperature, and, secondly, in the porous partition which surrounded the cathodes.

The function of this latter device was to enable the cathode hydrogen, which was given off in large quantities, to pass freely into the air without, as had previously happened, carrying with it a large quantity of chlorine gas, an action similar to that by which sulphurous acid fumes, which have such a corrosive action in badly supervised battery rooms, are carried into the air.

The cathode partition, or cell, must be extremely porous in order that the caustic soda liberated at the cathode may percolate back into the solution and reuniting there with the chlorine liberated at the anode, form an oxide of chlorine, usually regarded as hypochlorite of soda.

The particular test of which the writer gives particulars, showed, among other matters, the importance of the porosity of this cathode compartment. It had been the custom, in order to limit clogging of the partition, to lead the incoming unelectrolized saline liquor into the cathode compartments, whence, carrying with it a part of the caustic soda, a certain amount of fresh liquor was available for electrolysis, and caustic soda available for union with the chlorine to form the hypochlorite. The test in question was continued over 46

TABLE I.

TEST OF ELECTROLIZING PLANT PRODUCING SODIUM HYPOCHLORITE AT MAIDENHEAD, JULY, 1899.

TANK RECORDS

Hours since start.	D. P. Across Electrode terminals. Volts.	Litres of solution in tanks at end of period.	Grammes available chlorine per litre.	Specific gravity at end of period.	Yield in grammes of available chlorine per kilowatt hour during period.	Yield in grammes of available chlorine per kilowatt hour single start.	Yield in grammes of available chlorine per kilogramme of chlorine present in sodium chloride.	Rate of inflow of electrolyte into cathode cells, litres per cell per hour.	Tank temperature in C°.
0	—	2190	NIL	1.070	—	—	—	—	17.8
8	5.2	3070	1.78	1.087	240.4	240.4	34.1	8.56	20.6
16	5.2	2996	2.78	1.095	250.3	246.2	48.8	7.55	21.7
24	5.2	3276	3.58	1.098	217.7	236.8	60.9	6.24	22.5
32	5.1	3313	4.11	1.109	221.5	233.2	62.8	8.49	21.1
40	5.0	3482	4.60	1.114	208.2	228.1	67.3	6.92	22.2
48	5.0	3482	5.31	1.120	165.8	220.7	79.0	NIL	22.8

hours, during the last six of which no further liquid was fed into the cathode cells, with the result that the yield fell to a very marked degree.

In certain respects the first test is not a model one, but the exigencies of the situation are answerable for several of these, as large quantities of liquid had to be taken from the tank for immediate use for sewage sterilization. The initial voltage was rather in excess of that normally used, being 5.4 volts, while the specific gravity was at first somewhat low. Finally the voltage fell to 5.0 volts, and the specific gravity rose from 1.070 to 1.120.

Tests were taken at the end of each 2 hours, but for the purpose of conciseness only the values at the end of each 8 hours are reproduced in the accompanying diagram. The current was kept throughout at 500 amps. The available anode surface, counting each side of each anode, was 1,680 square inches, the cathode area being about 30 per cent greater, seven T-type platinum foil anodes being employed.

Table I. gives the chief results which are diagrammatically plotted in Fig. 2.

As has been stated, considerable quantities of the electrolyte were withdrawn from the main tank for the purpose of treating the sewage effluent, these withdrawals taking place as follows:

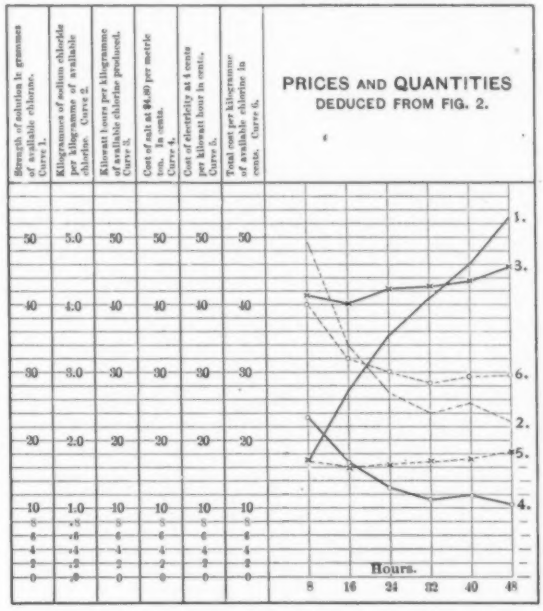

Strength of solution in grammes of available chlorine. Curve 1.
Kilogrammes of sodium chloride per kilogrammes of available chlorine. Curve 2.
Kilowatt hours per kilogramme of available chlorine produced. Curve 3.
Cost of salt at $4.80 per metric ton. In cents. Curve 4.
Cost of electricity at 4 cents per kilowatt hour in cents. Curve 5.
Total cost per kilogramme of available chlorine in cents. Curve 6.
PRICES AND QUANTITIES DEDUCED FROM FIG. 2.
50 5.0 50 50 50 50
40 4.0 40 40 40 40
30 3.0 30 30 30 30
20 2.0 20 20 20 20
10 1.0 10 10 10 10
Hours.
8 16 24 32 40 48
1.
3.
6.
2.
5.
4.

FIG. 3.—PRICES AND QUANTITIES DEDUCED FROM FIG. 2.

TABLE II.

PRICES AND QUANTITIES DEDUCED FROM TABLE I.

Strength of solution in grammes of available chlorine.	Kilogrammes of sodium chloride per kilogramme of available chlorine	Kilowatt hours per kilogramme of available chlorine produced.	Specific gravity of solution.	Cost of salt at $4.80 per metric ton. Cents.	Cost of electricity at 4 cents per kilowatt hour. Cents.	Total cost per kilogramme of available chlorine. Cents.
1.64	48.87	4.16	1.087	23.45	16.64	40.10
2.78	34.17	4.06	1.095	16.40	16.16	32.56
3.58	27.37	4.22	1.098	13.14	16.88	30.02
4.11	24.09	4.27	1.100	11.66	17.08	28.64
4.60	24.80	4.38	1.114	11.90	17.54	29.44
5.31	22.60	4.58	1.120	10.84	18.32	29.16

At the end of 8th hour, 769.5 liters containing 1.78 grammes average Cl per liter.

At the end of 18th hour, 688.5 liters containing 3.08 grammes average Cl per liter.

At the end of 26th hour, 580.5 liters containing 3.58 grammes average Cl per liter.

At the end of 34th hour, 418.5 liters containing 4.1 grammes average Cl per liter.

The test was not a model one, but, writing with the records before me of the working of a certain installation for upwards of two years, a model test is hard to find. Being of an unstable nature, it is a matter of extreme difficulty when producing hypochlorite solution to keep all the factors constant and vary only one of these. The causes of variations in efficiency of production during my various Maidenhead tests, included, in addition to variations in specific gravity, tempera-

ture variations within the tank, the difference between the temperature of the tank and of the surrounding air, variations in in-flow through the cathode cells, condition of these cells

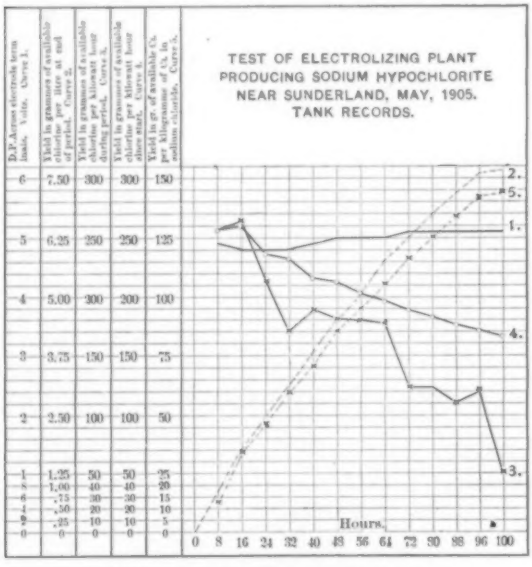

TEST OF ELECTROLIZING PLANT
PRODUCING SODIUM HYPOCHLORITE
NEAR SUNDERLAND, MAY, 1905.
TANK RECORDS.
D.P. Across electrode terminals. Volts. Curve 3.
Yield in grammes of available chlorine per litre at end of period. Curve 2.
Yield in grammes of available chlorine per kilowatt hour during period. Curve 5.
Yield in grammes of available chlorine per kilowatt hour since start. Curve 1.
Yield in gr. of available Cl. per kilogramme of Cl. in sodium chloride. Curve 4.
6 7.50 300 300 150
5 6.25 250 250 125
4 5.00 300 200 100
3 3.75 150 150 75
2 2.50 100 100 50
1 1.25 50 50 25
.8 1.00 40 40 20
.6 .75 30 30 15
.4 .50 20 20 10
.2 .25 10 10 5
0 0 0 0 0
Hours.
0 8 16 24 32 40 48 56 64 72 80 88 96 100
1.
2.
3.
4.
5.

FIG. 4.—TEST OF HYPOCHLORITE PLANT.

TABLE III.

TEST OF ELECTROLIZING PLANT PRODUCING SODIUM HYPOCHLORITE NEAR SUNDERLAND, MAY, 1905. TANK RECORD

Hours since start.	D. P. Across electrode terminals. Volts.	Yield in grammes of available chlorine per litre at end of period.	Yield in grammes of available chlorine per kilowatt hour during period.	Yield in grammes of available chlorine per kilowatt hour since start.	Yield in grammes of available chlorine per kilogramme of chlorine present in sodium chloride.
0	—	0	—	—	—
8	4.9	0.88	258.4	258.4	12.7
16	4.8	1.86	262.6	260.5	35.0
24	4.8	2.53	214.5	238.7	47.4
32	4.8	3.15	172.9	232.6	59.0
40	4.9	3.84	188.5	215.8	71.9
48	5.0	4.52	180.8	212.7	84.6
56	5.0	5.10	180.8	202.0	95.5
64	5.0	5.72	178.5	197.2	107.1
72	5.1	6.23	122.8	189.9	116.6
80	5.1	6.70	123.4	182.9	125.5
88	5.1	7.12	110.2	176.0	133.3
96	5.1	7.58	120.4	171.2	141.9
100	5.1	7.65	47.2	166.0	143.2

NOTE.

Specific gravity constant at 1.089.
Current constant at 200 ampers after first two hours.
Tank contents 2142 litres.
Minimum tank temperature 15.0C°
Maximum tank temperature 16.5C°.

as to porosity, mineral impurities in the electrolyte, and I am inclined to believe, but am not quite certain, variations in the barometric pressure of the atmosphere.

So far as this specific test is concerned, an important item militating against stability, and, therefore, against efficiency of production, lay in the temperatures attained. Tank temperatures to ensure stability should not exceed 18° C., and the more closely the tank and room temperatures approximate, the more stable the solution. During part of this run the engine room temperature was 29° C. However, within the actual range of the test the efficiency was, for a process of this character, very satisfactory, the current efficiency throughout being over 85 per cent. The figure given of the cost is a purely hypothetical one, based on a cost of electrical energy of 4 cents per kw-hour delivered at the tank terminals. To this would have to be added the cost of supervision, which would decrease with an increased plant capacity measured in kilogrammes of available chlorine per kw-hour per hour.

The final quantity of available chlorine present per liter was

TABLE IV.

PRICES AND QUANTITIES DEDUCED FROM TABLE III.

Strength of solution in grammes available chlorine per litre.	Kilogrammes of sodium chloride per kilogramme of available chlorine produced.	Kilowatt hours per kilogramme of available chlorine produced.	Cost of salt at $4.80 per metric ton. Cents.	Cost of electricity at 4 cents per kilowatt hour. Cents.	Total cost per kilogramme of available chlorine.
1.86	47.9	3.84	23.00	15.36	38.36
3.15	28.2	4.34	11.22	17.36	28.58
3.84	23.2	4.64	10.14	18.56	28.70
4.52	17.5	4.70	8.40	18.80	27.20
5.72	15.6	5.07	7.49	20.28	27.77
6.23	14.3	5.27	6.86	21.08	27.94
7.12	12.2	5.68	5.86	22.72	28.58
7.65	11.7	6.02	5.62	24.08	29.70

5.31 grammes. The ratio between the available chlorine produced and the quantity of chlorine present in the form of sodium chloride at the end of the test was only 7.9 per cent. Reckoning the quantity of sodium chloride used per kilogramme of available chlorine produced, the final figure of 22.60 kilos. was secured, a figure too high to permit of the commercial application of electrolytically produced hypochlorite solution in a number of directions.

The second test was carried out in the neighborhood of Sunderland early in 1905. As will be seen, the tank capacity was considerably less, a smaller current being employed, but the net results were financially more favorable. The available anode surface was considerably less, only four T-type anodes being employed (three of which had been in continuous use since the preceding trial), having an aggregate net anode area of 960 square inches, the cathode area being 25 per cent greater.

In this case no circulation of an incoming electrolyte through the cathode cells could be secured, and trouble was therefore experienced through the clogging of the cells, a fact which reacted rather severely upon the electrochemical efficiency. It will be observed that the economical range of production is greater, thanks to a saving in the amount of salt used, the final quantity of available chlorine present per liter was 7.65 grammes. The ratio between the available chlorine produced and the quantity of chlorine present in the form of sodium chlorine at the end of the test was 16.6 per cent. Reckoning the quantity of sodium chloride used per kilogramme of available chlorine produced, the final figure of 11.7 kilogrammes was obtained. The critical point; *i. e.*, the point of minimum cost of production, is between 4 and 5 grammes per

liter, a point which agrees with that of the earlier test, save that the combined costs are about 8 per cent less.

In regard to this latter test, the writer found out during the investigation from which the test is quoted, that the figures which are given of the yield during the period represent the net amount of available chlorine produced within the electrolyzing tank. The gross amount actually produced is in excess of the net production, by reason of the depreciation which has

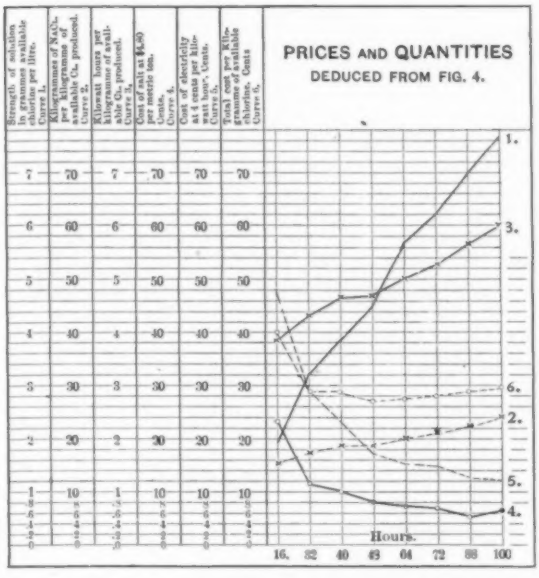


FIG. 5.—PRICES AND QUANTITIES DEDUCED FROM FIG. 4.

taken place. In a paper recently read before the Faraday Society, the writer has dealt with the effect of this during certain other tests.

Briefly, the whole question of the effect of depreciation upon efficiency at any given strength resolves itself into a matter of the ratio of tank contents to yield per hour. A depreciation at the rate of 1 per cent per hour is practically negligible when the capacity of the electrolyzing tank is equal to, say, 5 or 6 hours' output. When, however, the tank capacity represents several days' output, efficiencies, such as those indicated towards the close of the second test quoted, must, so long as hypochlorite solutions are even slightly unstable, be repeated. On other occasions, using a less volume of electrolyte, about 1,000 liters solution of 9 grammes of available chlorine were produced, with net efficiencies superior to those of the last 28 hours of the second test herein recorded. Details of these are not quoted, as they were not "start to stop" runs, but sequel runs with lessened volumes to other previous tests.

Reception to Prof. Ostwald.

A reception was tendered, on Feb. 2 by the New York Section of the American Electrochemical Society, to Prof. Wilhelm Ostwald, on the occasion of his return home to Leipzig. The hall of the Chemists' Club was beautifully decorated with evergreens and American and German flags, and there were present some 300 admirers of Prof. Ostwald. The speakers were Dr. C. A. Doremus, Prof. J. W. Richards, Prof. C. F. Chandler and Prof. Morris Loeb. Prof. Loeb, who spoke for the many old and recent students of Ostwald, presented a souvenir album, containing portraits of a few distinguished American chemists, with the autographs of those who were present at the reception. Prof. Ostwald's reply was a plea for esperanto—a universal language. The reception was an extremely enjoyable affair. Prof. Ostwald sailed for Germany on Feb. 6.

Metallurgical Calculations.

BY J. W. RICHARDS, PH. D.
Professor of Metallurgy in Lehigh University.

CONDUCTION AND RADIATION OF HEAT.

These two factors are of the greatest practical importance to the metallurgist, yet they are also the subjects of all others upon which the practical metallurgist is usually the most poorly informed. It often happens that a furnace is built of twice the capacity of its predecessor or of its neighbors, and the manager unexpectedly and most agreeably discovers that it keeps up a more uniform heat and requires considerably less than twice the amount of fuel to keep it running. Two reasons were operative: first, the walls were made thicker to support the heavier structure, but that made them also poorer conductors of heat; second, the capacity increased as the cube of a linear dimension, while the radiating surface increased as its square, so that radiation was, therefore, less than twice the primary amount from the furnace of double capacity. Many practical metallurgists have learned the practical results, but are entirely ignorant of the principles upon which the results are obtained. While it is well to be successful, it is better to be intelligently so.

PRINCIPLES OF HEAT CONDUCTION.

It is well known that the ability of metals to conduct heat is very nearly the same as their ability to conduct electricity. The order of metals in these two series is almost identical. Further, the specific conductance for heat is closely analogous to specific conductance for electricity. Just as we say that the electrical resistance of a conductor is proportional to its length and inversely as its cross-section, so we can make the same statement concerning heat resistance. Just as we can add electrical *resistances* when the bodies are in series, and must add electrical *conductances* when they are in parallel, so we can add heat resistances when the bodies are in line, and must add heat conductances when they are hooked up together in parallel.

The unit of electrical resistance is an ohm, and a substance has unit resistivity when a cube of it, 1 centimeter on a side, has that resistance. In such a case a drop of potential of 1 volt from one side to the opposite one sends through the cube 1 coulomb of electricity per second. Since conductivity is merely the reciprocal quality, actually and mathematically, to resistivity, the unit of conductivity is defined in exactly the same way, and the conductivity of any substance may be expressed as so many reciprocal ohms.

If we read in the preceding paragraph, thermal resistance for electrical resistance, degrees temperature for volts, and gram-calories for coulombs, we have defined the corresponding unit of thermal resistivity. A substance has unit capacity for conducting heat when a cube 1 centimeter on a side transmits 1 gram-calorie of heat per second, with a drop of temperature from one surface to the other of 1° C. Many investigators have adopted slightly different units, such as 1-kilogram-calorie per cubic meter per hour per degree difference; but such are only simple multiples or fractions of the centimeter-gram-second unit above defined.

Illustration:—If the thermal conductivity of copper is 0.92 units, what would be the amount of heat passing per hour through a sheet 1 millimeter thick and 1 meter square, with a constant difference of 1° C. between the two sides?

Solution:—The 0.92 units means that a column of copper 1 centimeter long and 1 square centimeter in cross-section, having a difference of temperature at its two surfaces of 1° C., would allow 0.92 gram-calories of heat to flow through it per second. For a sheet one-tenth as thick, 10,000 times the area, and during 1 hour, the heat passing per 1° C. difference will be

$$0.92 \times \frac{10}{1} \times \frac{10{,}000}{1} \times 3600 = 331{,}200{,}000 \text{ cal.}$$

$$= 331{,}200 \text{ Cal.}$$

Such calculations as the above are, of course, very useful for comparing different thicknesses of plates of different material, as to their relative heat-carrying capacity. With some slight modifications they are applicable to the actual conveyance of heat through such walls, from a fluid on one side to a fluid on the other. This introduces an idea analogous to transfer or contact resistance in electrolytic conduction. Thus, if we call R the thermal specific resistance (resistivity) in C. G. S. units, of the material of a partition having a thickness of d centimeters, and an area of S square centimeters, then the thermal resistance of the body of the partition will be

$$\frac{R \times d}{S}$$

and its thermal conductivity

$$\frac{S}{R \times d} = k$$

Besides this resistance in the body of the material there is transfer resistance at its two sides, or at its inner and outer surfaces, which depends on the materials which communicate heat and receive heat, and their velocity. These resistances may be expressed as so many units per square centimeter, the unit being of exactly the same nature as R, except that it connotes no thickness, but merely a surface effect. Calling R^1 the specific resistance of transfer from the inner fluid to the inner surface of the material, and R^2 the outside specific transfer resistance to the fluid outside, we can consider all three resistances as being in series, and the total thermal resistance to transfer from the inside fluid to the outside fluid to be

$$\frac{R \times d}{S} + \frac{R^1}{S} + \frac{R^2}{S}$$

or the thermal conductance of the system

$$\frac{S}{(R \times d) + R^1 + R^2} = k$$

The following table gives the thermal resistivity of various materials, in C. G. S. gram-Calorie units, also the thermal conductivity in units which are reciprocals of the resistance units:

Material.	*Conductivity. (in reciprocal resistance units.)*	*Resistivity. (in C. G. S. gram-Cal. units.)*
Silver (at 0°)	1.10	0.91
Copper (0° — 30°)	0.92	1.09
Copper, commercial	0.82	1.22
Copper, phosphorized	0.72	1.39
Magnesium	0.38	2.63
Aluminium (0°)	0.34	2.94
Aluminium (100°)	0.36	2.75
Zinc (15°)	0.30	3.33
Brass, yellow (0°)	0.20	5.00
Brass, yellow (100°)	0.25	4.00
Brass, red (0°)	0.25	4.00
Brass, red (100°)	0.28	3.57
Cadmium (0°)	0.20	5.00
Tin (15°)	0.15	6.67
Iron, wrought (0°)	0.21	4.76
Iron, wrought (100°)	0.16	6.25
Iron, wrought (200°)	0.14	7.14
Iron, steel, soft	0.11	9.01
Iron, steel, hard	0.06	16.67
German silver (0°)	0.07	14.28
German silver (100°)	0.09	11.11
Lead (0°)	0.084	11.90
Lead (100°)	0.076	13.16
Antimony (0°)	0.044	22.73
Mercury (0°)	0.015	66.67
Mercury (50°)	0.019	52.63
Mercury (100°)	0.024	41.67
Bismuth (0°)	0.018	55.55
Wood's alloy (7°)	0.032	31.25
Alloy, 1 Sn. 99 Bi	0.008	125.00

The last alloy, bismuth, with only 1 per cent of tin, is remarkable for its extremely low heat conductivity, less than one hundredth as good as copper. It has also the lowest electrical conductivity of any alloy, about one two hundredth that of copper. These peculiar properties ought to make it of use for some particular purposes.

The above data enables one to calculate the rate at which heat will pass through a metallic partition or wall when the temperature of its two surfaces is known. This is a very useful calculation, for in many cases the temperature inside a partition or pipe is known, or can be easily determined, and when the temperature of the outside surface is determined, the calculation can be made. The temperature of the outside of a partition or pipe can be found by several methods: one is to lay a very flat bulb thermometer (made especially for this purpose) against it; another is to put the junction of a thermocouple against it, covering the couple with a little putty or clay; another is to take small pieces of metals, or alloys of known melting points, and see which melts against the hot metal. The only uncertainty then in the calculation is the question as to what difference in the conductivity may be caused by the higher temperature. The conductivities in most cases decrease as temperature rises, but in others increase. There is here a large field for metallurgical experiment, in determining the heat conductivities of metals, alloys and fire-resisting materials at high temperatures.

Illustration:—An iron pipe, 6 centimeters in diameter outside and 5 centimeters inside, is filled with water at 10° C., and surrounded by hot gases at 198° C. From the rise in temperature of the water it is known that for each square centimeter of heating surface 0.084-gram calories of heat pass per second. Assuming the thermal conductivity of the iron (k) = 0.14, what is the difference of temperature of the two surfaces, inside and outside, of the pipe?

Solution:—The thickness of the walls is $(6 - 5) \div 2 = 0.5$ centimeter. If the walls were 1 centimeter thick, 1° difference would transmit 0.14 calorie; but being only half that thick, 1° difference would transmit 0.21-gram calorie. The actual difference of temperature of the two surfaces must then be

$$\frac{0.084}{0.28} = 0.3° \text{ C.}$$

Of course, such calculations can be turned around, and if the temperature of the inside and outside surfaces is known, the heat being transmitted can be calculated; or if the temperature of these two surfaces is known and the heat being transmitted is measured, the thermal conductivity of the partition can be reckoned; or, again, if the temperature of the two surfaces is known, and also the thermal conductivity of the partition, and the temperature of either fluid on either side, the thermal resistance of the transfer from either of the fluids to the surface of the partition can be calculated.

Illustration:—In the previous illustration the temperature of the hot gases was 198°, while that of the pipe in contact with them was practically 10°. What was the thermal resistivity of the transfer from gas to metal?

Solution:—The thermal resistivity is the reciprocal of the thermal conductivity, and in the case of this transfer resistance is the reciprocal of the number of gram calories which will be transferred to 1 square centimeter of pipe surface from the hot gases per second per each degree centigrade of difference of temperature causing the flow. This is a surface or skin resistance, and, therefore no linear dimension representing

thickness enters into the calculation. There is 0.084 calorie per second being transferred to each square centimeter of pipe, with a difference of temperature acting as propelling force of $198 - 10 = 188°$. The thermal conductivity of this transfer k is, therefore,

$$0.084 \div 188 = 0.00045$$

And the thermal resistivity, R, the reciprocal, viz.: *2222*. Since the thermal resistivity of the iron wall is $1 \div 0.28 = 3.57$ units, it follows that the contact surface offers $2222 \div 3.57 = 622$ times as much resistance to the flow of heat as the metal itself. In this specific instance, we can conclude that the transfer of heat from the gases to the pipe is the principal item which conditions the flow of heat, the passage of the heat through the wall of the pipe itself taking place 622 times as readily.

The valuable practical conclusion is that the thermal resistance of the walls of the pipe is insignificant as compared with the whole thermal resistance, and the thickening or thinning of the walls of the pipe, or the substitution of copper for iron, because of its greater thermal conductivity, is practically unnecessary for thermal considerations, since such can be expected to make practically no change in the thermal resistance of the whole system.

If the pipe under discussion, however, acquires during use a layer of scale deposited from the water, then the thermal resistance of the pipe or of the system is materially affected. A study of the thermal resistivity of various boiler scales would be a very useful and practical subject, but has not been done, as far as the writer is aware. Assuming a deposit, 0.5 centimeter thick, of material having the thermal conductivity of plaster of paris, for which $k = 0.0013$, the specific resistance of this material is $0.14 \div 0.0013 = 108$ times that of iron, and therefore 0.5 centimeter of this represents 54 centimeters thickness of iron. The thermal resistances in this case, neglecting that of transfer from the water to the pipe or scale, are as follows:

Resistance of transfer, gases to pipe $= 2222.0 = 85$ per cent

Resistance of 0.5 c.m. iron $= \dfrac{0.5}{0.14} = 3.6 = 0$ "

Resistance of 0.5 c.m. scale $= \dfrac{0.5}{0.0013} = 384.4 = 15$ "

Total $= 2610.0$

It thus appears that a deposit of scale from the water to a thickness of 5 millimeters increases the total thermal resistance of the system some 18 per cent of its original amount, and would cut down the efficiency of this part of the heating surface of a boiler by this amount. These considerations are not only of vital importance to the steam boiler engineer, but they are the essential principles which condition the efficiency of steam-heating apparatus, feed-water heaters, hot-air stoves and ovens, air-cooling of parts of furnaces and the efficiency of water jackets.

PRINCIPLES OF HEAT TRANSFER.

We have already had to speak of the transfer of heat from fluids to solids, or *vice versa*, and in one specific case we deduced the value *2222* for the transfer resistivity from hot gases to the surface of iron pipe, meaning thereby that for each degree of temperature difference between the gases and outside of the pipe 0.00045 gram-calorie passed per second through each square centimeter of contact surface. A consideration of the transfer of heat through such contact surfaces, from gases or liquids to solids and *vice versa*, has shown that the transfer resistivity varies with the solid and with the fluid concerned, but much more with the latter than with the former, and is very largely dependent upon the circulation of the fluid, that is, upon the rate at which it is renewed, and therefore upon its velocity. The conductivity or resistivity of such a transfer must, therefore, contain a term which includes the velocity of the fluid. Various tests by physicists have shown the specific conductance (or conductivity of transfer) to vary approximately as the square root of the velocity of the fluid.

From metal to air or similar gases, the mean velocity of flow being expressed in centimeters per second, and the other units being square centimeters and gram-calories, the transfer resistivity is approximately

$$R = \frac{36{,}000}{2 + \sqrt{v}}$$

and the transfer conductivity of the contact

$$k = 0.000028\ (2 + \sqrt{v})$$

From hot water to metal the relations are similar, but the conductivity is much better. Experiments show values as follows:

$$k = 0.000028\ (300 + 180\sqrt{v})$$

$$R = \frac{36{,}000}{300 + 180\sqrt{v}}$$

Illustration:—In the preceding case of the iron pipe, calculate the difference of temperature of the water in the pipe and the inner surface of the pipe, assuming the water to be passing through at a velocity of 4 centimeters per second.

Using the above given formula, the heat transfer per 1° difference would be

$$0.000028\ (300 + 180\sqrt{4}) = 0.0185 \text{ calories,}$$

and the difference to transfer 0.084 calories per second will be

$$\frac{0.084}{0.0185} = 4°.6$$

The inner surface of the iron pipe will be, therefore, continuously 4°.6 higher than the water, and, therefore at 14°.6; the outer surface will be continuously 0°.3 higher, or practically at 15°.

Illustration:—A steam radiator, surface at about 100° C., caused a current of hot air to rise having a velocity of about 10 centimeters per second, which was insufficient to keep the room warm. An electric fan was set to blow air against the radiator, which it did with a velocity of about 300 c.m. per second, and keeping the room comfortably warm. What were the relative quantities of heat taken from the radiator in the two cases?

The relative thermal conductivities of transfer were

$$2 + \sqrt{10} : 2 + \sqrt{300}$$

or $5 : 16$

Showing over three times as much heat taken away per unit of time in the second instance.

This illustration proves the great efficiency which the metallurgist may attain in air cooling of exposed surfaces, by blowing the air against them instead of merely allowing it to be drawn away by its ascensive force.

Problem 21.

Hot air of the volume of 33,000 cubic meters per hour passes through an iron pipe exposed to the air, 30 meters long, 1.5 meters inside diameter, thickness of walls 1 centimeter, and lined inside with 5 centimeters of fire-brick. Assume the hot air entering at 1,000°, the outside air to be at 3°, the coefficient of internal transfer $0.000028\ (2 + \sqrt{v})$, the conductivity of the fire-bricks 0.0014, of the iron 0.14, of external transfer $0.000028\ (2 + \sqrt{v})$, the velocity of the wind against the outside 6 kilometers per hour.

Required:—The temperature of the hot air leaving the tube.

Solution:—The mean temperature in the tube is the factor which conditions the mean velocity in the tube, and the rate of flow of heat towards the outside. If, therefore, we let t repre-

sent that mean temperature, the solution can be stated in the simplest terms. We then have:

Volume of air per hour, at 0°, $= 33{,}000$ cubic m.

Volume of air per second, at 0°, $= 9.167$ "

Volume of air per second, at t, $= 9.167 \dfrac{t+273}{273}$

$$\frac{1000}{3600}(19{,}998{,}000 - 16.414\,t - 3.564\,t^2) =$$

$$\frac{1}{\dfrac{1}{0.000028\,(2+\sqrt{595\,(1+\alpha t)}} + \dfrac{1}{0.00028} + \dfrac{1}{0.14} + \dfrac{1}{0.000515}} \times 1{,}423{,}000 \times (t-3)$$

Cross-section of inside of tube

$(1.5 - 0.1)^2 \times 0.7854 = 1.54$ sq. m.

Velocity of air at t, in pipe

$$9.167\,\frac{t+273}{273} \div 1.54 = 5.95\left(\frac{t+273}{273}\right) \text{ m. p. s.}$$

$$= 5.95\,(1+\alpha t) \text{ m. p. s.}$$

$$= 595\,(1+\alpha t) \text{ c.m. p. s.}$$

Coefficient of internal transfer $=$

$$0.000028\,(2+\sqrt{595}\,)\,(1+\alpha t)$$

Coefficient of conductance of 5 c.m. of fire-brick lining $=$

$$0.0014 \div 5 = 0.00028$$

Coefficient of conductance of 1 c.m. of iron $=$

$$0.14 \div 1 = 0.14$$

Coefficient of external conductance ($v = 278$ c.m. per sec.) $=$

$$0.000028\,(2+\sqrt{278}) = 0.000515$$

Total fall of temperature of air $= 2\,(1000 - t)$

End temperature of the air $= 1000 - 2\,(1000 - t)$

$$= 2t - 1000$$

Mean specific heat of air per cubic meter between 1000 and end temperature $=$

$$0.303 + 0.000027\,(2t)$$

Heat given out by the air per hour $=$

$$33{,}000 \times 2(1000 - t) \times (0.303 + 0.000027\,(2t)) =$$

$$19{,}998{,}000 - 16.414\,t - 3.564\,t^2$$

This heat is the quantity transferred through the pipe in kilogram calories. The outside surface of the pipe may be taken as the conducting surface, because the larger part of the resistance to the flow of heat takes place there. If we desired to be more exact, the mean area of iron, fire-bricks and the inner surface could be each used separately. The outside diameter being 152 centimenters, and the length 30 meters, the outer surface is $1.52 \times 3.1416 \times 30 = 142.3$ square meters $= 1{,}423{,}000$ square centimeters, the total driving force is the inside temperature minus that outside, or $t - 3$, and the total thermal resistance is the sum of the four thermal resistances in series, that is, the sum of thermal resistance gas to fire-bricks $=$

$$\frac{1}{0.000028\,(2+\sqrt{595\,(1+\alpha t)}}$$

thermal resistance of fire-brick lining $=$

$$\frac{1}{0.00028}$$

thermal resistance of iron shell $=$

$$\frac{1}{0.14}$$

thermal resistance of iron to air $=$

$$\frac{1}{0.000515}$$

The reciprocal of the sum of these four resistances is the thermal conductance of the system per square centimeter, which, multiplied by the conducting surface, 1,423,000 square c.m., and by the total difference of temperature, $t - 3$, gives the heat transferred per second in gram-calories.

We, therefore, have the final equality expressed as the heat given up by the air, per second, equals the heat transmitted to the outside air per second; *i. e.*,

Whence $t = 965°.5$

And the temperature of the air at the end of the tube is

$$2t - 1000 = 931° \qquad (1)$$

It would be interesting to compare the temperatures of the inside and outer surfaces of the tube. The air inside is at a mean temperature of 965°, the heat transmitted per second is 0.1574-gram calories per square centimeter of outer surface, whose thermal conductivity is 0.00515, and, therefore, the outside surface must be

$$\frac{0.1574}{0.000515} = 306°$$

hotter than the surrounding air; that is, must be at 309° C.

The extra loss of heat by radiation from this outside surface would be small at that low temperature, but has not been allowed for in the working of the problem.

For such metallurgical problems we need the data as to the thermal conductivity or resistivity of ordinary furnace materials. These have been determined in but few instances, and in most cases not at the high temperatures at which they are practically used. A whole series of physico-metallurgical experiments is needed just upon this point. The following are probably nearly all that have been determined and the values published. The unit k is the C. G. S.-gram calories unit, the same as used for the metals.

	k.
Ice (datum useful in refrigerating plants, where pipes become coated with ice, as in Gayley's method of drying blast)	0.00500
Snow	0.00050
Glass (10° — 15°)	0.00150
Water	0.00120
Quartz sand (18° — 98°)	0.00060
Carborundum sand (18° — 98°)	0.00050
Silicate enamel (20° — 98°)	0.00040
(Explains the small conductance of enamelled iron ware.)	
Fire-brick, dust (20° — 98°)	0.00028
Retort graphite dust (20° — 100°)	0.00040
(Datum useful where articles are packed in this poorly conducting material.)	
Lime (20° — 98°)	0.00029
(Datum would be highly useful for oxyhydrogen platinum furnaces, if it were only known at high temperatures.)	
Magnesia brick, dust (20° — 100°)	0.00050
Magnesia calcined, Grecian, granular (20° — 100°)	0.00045
Magnesia calcined, Styrian, granular (20° — 100°)	0.00034
Magnesia calcined, light, porous (20° — 100°)	0.00016
Infusorial earth (Kieselguhr) (17° — 98°)	0.00013
Infusorial earth (0° — 650°)	0.00038
Clinker, in small grains (0° — 700°)	0.00110
Coarse ordinary brick dust (0° — 100°)	0.00039
Chalk (0° — 100°)	0.00028
Wood ashes (0° — 100°)	0.00017

Powdered charcoal (0° — 100°)	0.00022
Powdered coke (0° — 100°)	0.00044
Gas retort carbon, solid (0° — 100°)	0.01477
Cement (0° — 700°)	0.00017
Alumina bricks (0° — 700°)	0.00204
Magnesia bricks (0° — 1300°)	0.00620
Fire-bricks (0° — 1300°)	0.00310
Fire-bricks (0° — 500°)	0.00140
Marble, white (0°)	0.0017
Pumice	0.0006
Plaster of paris	0.0013
Felt	0.000087
Paper	0.00040
Cotton	0.000040
Wool	0.000035
Slate	0.00081
Lava	0.00008
Pumice	0.00060
Cork	0.00072
Pine wood	0.00047
Oak wood	0.00060
Rubber	0.00047

A study of the above table will in many cases show the metallurgist how conduction of heat can be checked, and to what degree. The substance chosen must be able to stand the temperature without being destroyed; but it is in many cases possible to use one kind of material inside, where the heat is greatest, and a material of much poorer conductivity outside, where the heat will not destroy it. Such compound linings or coverings may be very advantageous. Infusorial earth is one of the very best insulators for moderate temperature; above a bright red it loses efficiency greatly, and is then hardly better than powdered fire-brick.

RADIATION.

A body placed in a vacuum, with no ponderable substance in contact with it, radiates heat to its surroundings. As far as experiments have gone they show the reliability of Stefan's law, that the amount of energy radiated is proportional to the difference between the fourth process of the absolute temperature ($C° + 273$) of the hot body and of its surroundings. With the surroundings at 0° and the hot body at 100°, Peclet determined the following amounts of radiation which we give here in C. S.-gram calorie units, that is, the number of gram calories radiated per square centimeter of surface, per 0° to 100° difference of temperature, with the understanding that this quantity gives the heat radiated in the range 100° and 0°. For other ranges of temperature Stefan's law would have to be used, starting with these figures as a basis; that is, the quantity of heat radiated from 100° to 0° represents a difference of 13.8×10^8 between the fourth powers of the absolute temperatures 273 and 373, and for any other numerical difference between the fourth powers of the two absolute temperatures concerned, a corresponding value for the heat radiated in that range could be calculated.

Polished silver	0.00054
Silvered paper	0.00177
Polished brass	0.00108
Copper	0.00068
Zinc	0.00102
Tin	0.00090
Polished sheet iron	0.00189
Leaded sheet iron	0.00273
Ordinary sheet iron	0.01164
Russian sheet iron	0.01410
New cast iron	0.01332
Oxidized cast iron	0.01410
Glass	0.01222
Paper	0.01583
Lamp-black	0.01684
Building stone	0.01500
Plaster	0.01500
Wood	0.01500

In order to save calculation we may deduce from Peclet's experiments that the heat radiated for other ranges of radiating temperatures is relatively (calling the above figures unity):

100° to 0°	(surroundings)	1.0
150°	"	2.0
200°	"	3.3
300°	"	7.0
400°	"	12.0
500°	"	18.3
600°	"	26.0
700°	"	35.0
800°	"	45.3
900°	"	57.0
1000°	"	70.0

It it is thus possible to calculate the heat radiated from a hot surface, and to add it to the heat transferred to the air by contact. In practice the total heat loss from the outside surface equals the total heat coming through the walls, which at the outer surface splits into two parts. The one is transferred to air by contact, calculated from the laws of transfer already discussed, and the other radiated freely without contact, and calculated from the data just given. If the temperature of the outer solid surface is carefully taken, both of these amounts of heat can be calculated, and the sum is the total heat being lost by transmission through the wall of the furnace.

Containers for Alkaline and Lead Accumulators.

BY M. U. SCHOOP AND C. LIAGRE.

For accumulators with caustic potash or soda solutions as electrolyte it is absolutely necessary that the container be absolutely dense and not attacked by the electrolyte.

Materials which satisfy these requirements are hard rubber and iron or steel. Glass is slowly attacked with the formation of silicate, wood is attacked with the formation of oxalate.

The following notes are intended to sum up the present status of the art of manufacture of containers of hard rubber and sheet steel:

HARD-RUBBER CONTAINERS.

Hard rubber (ebonite, vulcanized rubber) is produced by treatment of a mixture of rubber and sulphur at a high temperature. According to the duration of the vulcanizing process, and according to the proportions of rubber and sulphur in the mixture, it is possible to produce any desired degree of elasticity, so that a very soft and elastic material or a hard and brittle one may be produced at will.

It is now possible to produce a material, perfect in quality in every respect, while most hard-rubber boxes which were on the market five or seven years ago, left much to be desired. The density of hard rubber is about 1.2. Pure hard rubber is insoluble in caustic solutions. For containers for alkaline accumulators the use of this material, therefore, suggests itself. But even hard-rubber receptacles of best quality have some disadvantages; they are breakable and are sensible to strong variations of temperature. For instance, at low temperatures cracks may occur spontaneously, while with a hot electrolyte the hard rubber becomes plastic, so that changes of form take place.

The thickness of hard-rubber walls cannot be less than 3 millimeters (about ⅛ inch), while with larger dimensions of the vessel the thickness of the walls must be 4 or 5 millimeters (160 to 200 mils). On the other hand, with metallic containers, it is possible to make the walls not more than 0.4 to 0.6 millimeter thick (16 to 24 mils). For a complete automobile battery of forty-four cells this represents a considerable difference in volume. Moreover, by the use of metal containers a diminu-

tion of weight is realized which may amount to 50 per cent. Finally, it should be taken into consideration that hard-rubber containers are quite expensive, and that storage battery factories are usually not in a position to undertake the manufacture, so that they must depend to some extent on the manufacturers of hard-rubber boxes. It will be shown below that the manufacture of metallic boxes offers no special difficulties, so that they may be made in the storage battery factory itself.

However, hard-rubber containers will undoubtedly maintain, for some time to come, their prominent position for all those purposes in which transportable lead accumulators are used. Besides, hard rubber is very suitable for insulating purposes within the alkaline accumulator. For these reasons a discussion of the properties peculiar to hard-rubber material should not be without interest, especially as the following notes are based on practical experience.

Pure hard rubber, which would contain no other substances but rubber and sulphur, would cost from 15 to 20 francs per kilogram (about $1.40 to $1.80 per pound). This is a price which would be out of all proportions to the present prices of storage batteries.

It is, therefore, easily understood that the commercial hard rubber contains all possible substitutes and is very often almost anything but a vulcanized mixture of rubber and sulphur. Nevertheless, it is possible to make fairly good boxes with a minimum of rubber, in spite of the use of foreign organic materials, of which the following are mostly used: Resin, pitch, fat oils, bitumen, and especially artificial rubber, so-called "factis." Factis is obtained by vulcanizing for some time various vegetable oils with minium or magnesium peroxide, or sometimes with a mixture of boiled linseed oil and sulphur. Factis is not attacked by sulphuric acid of the usual density, but is attacked by caustic solutions. The use of "factis" in hard rubber is, therefore, of no account as long as the containers are intended for lead accumulators, but should not be permitted for containers of alkaline accumulators. The presence of "factis" may be easily proven by treating a sample of the hard-rubber material with alcoholic caustic soda.

There is also a large number of mineral substitutes. Among them are barium sulphate, talcum, asbestos, in form of a powder, kaolin, lime, magnesium carbonate, silicon, zinc oxide, lead carbonate, lead sulphide and minium. In many cases hard-rubber scrap is also added. If the scrap is obtained from different hard-rubber makes, this method is extremely dangerous, since in this way all possible foreign materials may get into the final product, and in the end no longer any control is possible.

In Table I. we give the results of analysis of hard-rubber containers made by different companies.

Table I.

	Sold as Pure Para	Different Samples of Hard Rubber				
Specific weight.....	1.20	1.45	1.53	1.35	1.65	1.58
Water	0.30	1.00	0.40	1.00	0.40	0.65
Ash	1.50	(1) 23.50	(2) 31.00	(3) 27.50	(4) 46.25	(5) 49.00 (6)
Sulphur combined....	5.50	11.00	13.50	12.50	8.75	5.50
Sulphur free.....	6.00	9.00	12.00	traces	5.75	0.50
Resins and fat oils (soluble in CS_2)....	2.00	4.00	5.00	9.50	—	1.50
Rubber and "factis".	84.10	51.50	38.16	49.6	32.85	42.85

(1) Aluminium silicate, chalk, iron oxide.
(2) Magnesium silicate.
(3) Magnesium silicate, chalk, silicon, iron oxide.
(4) Barium sulphate, chalk, lead carbonate.
(5) Magnesium silicate, chalk.
(6) Magnesium silicate, iron oxide.

Besides the use of substitutes, which may cause trouble (though this does not necessarily follow), certain flaws, due to the method of manufacture, may occur which shall now be briefly discussed.

Hard-rubber containers are made as follows: Rubber is first mixed with sulphur and, after adding the other materials which are used as substitutes, the mixture has a degree of consistence like gutta-percha.

This dough is rolled by calenders, is cut in pieces of proper size and placed on the pattern, which may be made of cast iron or of an easily fusible metal (lead-antimony alloy), and which has the inside dimensions of the container to be made. Metallic plates, mostly of cast iron, are then pressed on from the outside; they determine the outside dimensions of the hard-rubber box. These outer cast-iron plates are maintained in position by screws. The whole block (containing the hard-rubber pieces between the inside metal pattern and the outside metal plates) is now placed in the vulcanizing vessel.

The flaws, which occur most frequently, are due to air bubbles enclosed in the hard rubber or to conducting foreign substances, like graphite, pieces of metal, etc.

In order to determine the reliability of the finished boxes and to test the homogeneity of the hard rubber, the following method of testing the boxes with the induction coil is to be recommended:

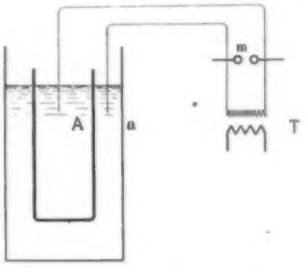


FIG. I.—TESTING HARD-RUBBER CONTAINERS.

The container *A* to be tested (Fig. 1) is partly filled with water and placed in a vessel *a*, which is also filled with water. The two liquids are, therefore, separated from each other by the hard-rubber walls of the box *A*. Connections are then made with the secondary poles of an induction coil (or transformer) *T*.

Care must be taken that the upper part of the hard-rubber box, which is above the water level, is well dried, since the sparks would otherwise jump above the top. The spark length *m* is now adjusted and the induction coil is set into operation. The length of the spark gap *m* depends, of course, on both the thickness and the quality of the hard rubber, as well as on the induction coil. If the latter gives, for instance, in air a spark length of 30 centimeters, the distance between the brass globes is diminished until a continuous spark discharge takes place. One will find in this way a spark length of about 5 to 6 mm. per mm. of wall thickness, on the supposition that the hard rubber is perfect in every respect. With too great a spark length sparks pass no longer, but the so-called silent discharge takes place. If the spark length is too short, it is also impossible to detect any flaws in the hard rubber, since the sparks, of course, pass along the path of minimum resistance.

With some experience and with proper adjustment of the distance between the brass knobs, it is easy to detect small flaws of manufacture. One has to observe whether the sparks stop playing or a visible discharge passes through the hard-rubber wall. If, in this way, a flaw is detected in the hard rubber this flaw is suitably burned out, and any conducting foreign bodies are thereby definitely removed. The box is then pasted at the place of the flaw with gutta-percha or with a thick solution of para and bisulphide of carbon, and is vulcanized a second time.

In most cases repairs do not offer good prospects of permanent success, so that it is better not to use at all containers having flaws.

When hard rubber, which contains other substances, especially fat oils, mixed with the rubber and sulphur, is brought in contact with a caustic solution (as used in the Edison accumulator), troublesome formation of foam occurs.

(To be concluded.)

Smoke Abatement.—This subject was discussed by the New York Section of the Society Chemical Industry on Feb. 23. The speakers were Health Commissioner T. Darlington, Mr. A. de Trampe, Mr. L. H. White, on down-draught furnaces; Mr. Walker Bowman, on filtering smoke; Mr. E. H. Foster and Mr. A. A. Cary, on furnace construction.

Notes on Electrochemistry and Metallurgy in Great Britain

(From Our Special Correspondent.)

METALLURGICAL PAPERS READ DURING JANUARY.

Those attending the January meeting of the Institution of Mining and Metallurgy had four papers for their consideration, which were discussed in the following order:

(1) "Notes on Metals and Their Ferro-Alloys Used in the Manufacture of Alloy Steels," by O. J. Steinhart.

(2) "Pyritic Smelting," by R. C. Alabaster and F. H. Wintle.

(3) "The Acme Combined Concentrating Table," by L. H. L. Huddart.

(4) "Stadia in Careful Work," by A. H. Webb.

FERRO-ALLOYS.

Dr. Steinhart's paper can be dealt with only in abstract.

"There are many people who, having found some of those rarer minerals which are used as raw material for the production of metals in question, have formed erroneous and exalted ideas as to their consumption and value. These mistakes have in many cases been the outcome of the want of reliable information, which is frequently most difficult to obtain, the steel makers and manufacturers of these metals being, not unnaturally, somewhat reticient as to details. Before dealing more fully with the various metals and alloys forming the subject of these notes, it is well to state at the outset that the present-day requirements of the steel makers with respect to the purity of the elements they add to the various steels are most stringent and exacting, and those intending to evolve a new method, or wishing to add another metal or alloy to the already not inconsiderable list of the latter, should bear this in mind. The fatal effects which very small quantities of such elements as sulphur, phosphorus, etc., have upon steels form such elementary knowledge that it goes without saying that none of these should be present to any appreciable extent in the materials added to the steel." Another point often overlooked by novices is the presence of several per cents of carbon, so often found with electric furnace products, which are as undesirable as the other impurities just referred to. Therefore, generally speaking, the freer the metals and alloys are from these interfering substances the more welcome they will be to the steel maker, and the better will be the prices paid by him. The great changes brought about in the recent industrial development and application of the electrical furnace, based chiefly upon the early laboratory experiments of H. Moissan, have had a most important bearing upon the manufacture of our alloys and metals, but experience has shown that quite a number of these, as for instance, nickel and tungsten, are still best prepared by the older chemico-metallurgical methods, chiefly on account of the difficulty of producing pure low percentage carbon alloys in the electrical furnace. The Goldschmidt aluminium reduction process has likewise yielded a ready method for preparing the pure metals and alloys, although they are somewhat costly. The metals and their ferro-alloys used by steel makers in the order of their consumption and importance are probably as follows: Manganese, nickel, chrome. tungsten, molybdenum, vanadium, and also, experimentally, cobalt, titanium, uranium, and recently tantalum.

On the purely electrometallurgical side Dr. Steinhart had much to say. With regard to nickel, reference was made to Mr. Ulke's contribution to *Electrochemical Industry* in 1903, and the following remarks were added: Lately semi-metallic granules and scraps easily produced by reducing nickel-oxide were substituted for cast-nickel anodes, and thus the cost of refining was reduced to less than 1 cent per pound of refined nickel. Quite a number of processes have been evolved by Frasch, Ulke, Hopfner and others, with the object of dealing with copper-nickel mattes. The matte was generally either electrolyzed in a solution, such as ferricsulphate, cupric, chloride, sodium chloride, sulphuric or other acids and the metals deposited from the mixed electrolyte by fractional electrolysis, or the matte was first leached with a suitable solution and the metals thrown down by the current. On the whole, these processes are very complicated, and have not led to any practical results, although some nickel has been produced at large experimental installations. (See, however, the description of the successful Brown in our Vol. I., pp. 348, 381.—Ed.) The Lake Superior Power Co., in 1902, attempted, in conjunction with E. A. Sjostedt, to produce ferro-nickel in the electrical furnace from dead-roasted Canadian ores, but this process never came into practical use, although a large plant was put down. On the other hand, the companies, "La Societe Electrometallurgique de Froges" and "Le Ferronickel," have produced ferronickel commercially. Dr. Steinhart regretted, however, to say that he was unable to obtain any information from these concerns.

With regard to chromium, some new information—new at least in England—was supplied concerning the Willson Aluminium Co., of New York, who have electric furnaces at Kanawha Falls and also at Holcomb Rock, both in Virginia. Kanawha Falls uses three dynamos of 800 kw. each, and those at Holcomb Rock one-third of that power. Alternating current of 110 volts pressure is used at Kanawha Falls, the current of 22,000 amps. being divided over seven furnaces, all crucible furnaces of partly circular, partly square and rectangular cross-section. The combined works can turn out about 200-250 tons of ferrochrome per month. The quality of the ferrochrome seems to be improving every year. At one time the alloy was rather soft and high in carbon. They can now turn out ferrochrome of good solid quality, testing 5-6 per cent maximum carbon.

Where special low carbon steels are required alloys containing as little as 1.271 per cent, or even 0.555 per cent, are obtainable. Passing reference was also made to Dr. Goldschmidt's aluminothermic process, chromium produced by it having considerable purity (from 97.41 to 99.55 per cent in the case of two analyses cited), but being rather expensive, at from 2s. 3d. to 2s. 6d. per pound.

As regards tungsten, the chemistry of various methods of treating wolfram ores was discussed, and the samples of ferrotungsten from the electrical furnace which had come under Dr. Steinhart's notice were characterized as "not very pure or suitable for tungsten steels." Mention was also made of the occurrence, treatment and applications of molybdenum and tungsten. As Dr. Steinhart confessed, it was impossible, even in a remote manner, to touch upon the special characteristic properties which the metals under consideration imparted to steel and iron. Much of the descriptive matter had been purposely omitted as to the properties of the metals and minerals, facts which could be found in any good text-book on chemistry and metallurgy. Finally, it might be said that with the many pure metals and alloys now at their disposal, the number of useful alloy steels which may be produced from these offers a field of such gigantic magnitude that it required a master mind and ceaseless investigation to select those which should give a desired result with the least expenditure.

EXPIRING BRITISH ELECTROCHEMICAL AND ELECTROMETALLURGICAL PATENTS.

Compared with the United States or Germany the number of patents which have run their full term and are about to expire during any year, are relatively very few in England. The system of intermittent payments of fees, and the immediate lapsing of any patent on the fees being unpaid, weeds out a large number of patents which would remain in force where a single outright payment is made at the outset. Therefore, in chronicling the survivors expiring this year (unless specially extended by recommendation of the judicial committee of the Privy Council), only a few are of interest to readers of this journal, and may be considered under four headings.

Firstly, of these connected with electrolytic alkali industry, mention must be made of No. 9,347, of 1892, issued to Carl Kellner, which is concerned with the separation of the undecomposed sodium chloride from electrolytically produced caustic soda. The methods in use consist in mechanical separation of the sodium chloride crystals by sieves from a heated vessel, the washing of the crystals and evaporation of the resultant liquor. It is claimed that this arrangement, by separating the alkali contained in the solution by repeated and systematic displacement by means of brine, will allow of the alkali being obtained in an almost pure condition, and that the whole of the residual undecomposed electrolyte is separated and returned into the cycle (of evaporators, displacement vessels, etc.). Another patent, by H. Young Castner, No. 16,042, of 1892, which invention is described as consisting of the employment of a mechanically moving body of Hg, or other liquid metal or alloy between the anode and cathode departments of a decomposing cell, so that the current must flow through the moving metal. This is claimed to reduce the counter-electromotive force, and render it possible to carry on the action with a very high current efficiency. Another patent, Charles Kellner's, No. 17,169, of 1892, in which the cathode is formed of a thin film of mercury contained in partitions permitting a free passage to the current. Various methods of making the troughs are described, such as a wooden trough lined with paraffined linen and provided with a groove in which is acid-proof cement. Sodium forms an amalgam with the mercury and is converted by water into caustic soda. The patent claims that this apparatus can also be used for separating other metals forming an amalgam with mercury. As a contrast to the mercury cathode cells, one of the Hargreaves-Bird patents also expires (No. 18,039, of 1892). This describes a cathode formed of wire gauze or perforated metal, on the anode side of which is material constituting a porous diaphragm. The porous diaphragm consists of a layer of fibrous material next the cathode, and a layer of stone-like material on the fibrous material. Briefly described as an improved electrode, made by depositing the materials which form it (asbestos or Portland cement, or plaster of paris) in the form of pulp, either direct on the gauze or on paper or felt laid on the gauze. A mixture of clay and silicate of soda is also used.

Of the metallurgical patents, No. 18,516, of 1892, is concerned with the obtaining of homogeneous deposits of metals. It was granted to E. N. A. Picard and J. A. Taniere, and covers the continuous hammering of the metal being deposited by means of an electromagnetic-trembler device. Two patents standing in the name of Mr. T. L. Willson also expire; of these, No. 21,696, of 1892, covers a process bringing the metallic compound in a state of extremely fine sub-division into most intimate contact with a reducing agent before subjecting it to an electrical smelting process. It is applied to porous alumina or other metallic oxides. The inventor steeps it in a hydrocarbon until all the liquid is absorbed. Coal-tar, or heavy hydrocarbon oil or paraffin, is used, also salt. The other, No. 21,701, of 1892, relates to the treatment of refractory metallic compounds by mixing with carbon in sufficient proportion to prevent the formation of a bath of molten metal boiling up, and so short-circuiting the furnace.

Two of Emile Andreoli's ozonizer patents expire, both being concerned with the details of the electrodes. The earlier, No. 9,631, of 1902, relates to the production of ozone by silent electrical discharges from point-bearing metallic electrodes. The electrodes here described are, some, in the form of a comb, others are double spiked plates set between two metal electrodes, from which the points are separated by glass, mica, etc. The double-pointed plate is attached to one terminal of a Ruhmkoiff coil. Enamel may be used as the separating substance instead of glass or mica. Various forms of utilizing these electrodes are described, either with a natural draught or with air forced in by a pump. The later patent, No. 21,794, of 1902, is a development of the former patent, and relates to the use of plates of metal cast, cut or stamped, so as to form sharp edges, tongues or angles to act as points for the discharges. One showed in appearance like fret-saws strung on a frame.

For the electrolytic production of oxygen and hydrogen only one patent, P. Garuti's, calls for mention, being No. 16,588, of 1902. It provides for a lead-lined bath divided into sections by metallic longitudinal partitions, each containing one anode and two cathodes. Two large cup-like chambers receive the discharging gases, the cells giving off the gas separately. The use of metal diaphragms for separating the cells is claimed as offering small resistance.

In regard to secondary batteries mention may be made of H. W. Headland (No. 15,120, of 1892), entitled "Improvements in Accumulator Plates," which are to be built up of hollow tubes or bars, pierced with numerous holes, and filled with paste, which projects through the holes. There are also No. 22,987, of 1892 (W. W. Griscom), for lead plates first pitted by the action of an alkaline solution, and then formed in the familiar Plante manner, and No. 24,127, of 1892 (F. King), for special plates having projections or pins covered with an insulator touching the opposite plates, the object being to support the plates and to limit buckling.

The Council of the Faraday Society.

At the meeing of the Society on Jan. 30, the nominations for the Council for 1906-07 were announced. Lord Kelvin retains the presidential chair for another twelve months, and the new vice-presidents (in place of Mr. Swinburne and Alexander Siemens) are Prof. A. Crum Brown and Prof. Hittorf. From the Council, Mr. Cowper-Coles and Mr. G. T. Beilly retire by rotation, and are to be replaced by Dr. T. M. Lowry and Mr. W. R. Cooper.

The January Meeting of the Faraday Society.

Again a "three-paper evening." Virtually, but not literally, for doubts were expressed as to whether the first contribution was a paper at all, and the second was frankly a demonstration.

We began with the third instalment of M. Adolphe Minet's compilation of notes on electric furnaces. This was the third paper presented to the Faraday Society. How many more there will be one does not know; perhaps the grandchildren of the present Council may closure the series. Whatever be the number of succeeding papers one thing is manifest, and that is their potential archæological interest.

Monsieur Minet being absent, Mr. Murray Morrison acted in *loco parentis* in the first instance. Later on, expressing his pleasure at having acted as intermediary, he personally disclaimed identity with many of M. Minet's views and historical data. Free from the trammels of deputyship, Mr. Morrison was interestingly retrospective. For instance, one of the Héroult's patents, described by Minet as dating back to 1887, really dated back to early in 1886 or late in 1885, a dishonest patent agent annexing the fees first sent. As to the author's figures, of the aluminium output and power used, they "were not at all accurate." As director of the British Aluminium Co. he regretted he was not at liberty to controvert certain figures. Referring to the early history of aluminium, the speaker observed that, initially, aluminium had been regarded as only useful for alloys, and when Héroult first offered to produce cheaper aluminium he was advised to confine his attention to alloys.

Dr. Borns then pertinently asked whether the paper should have been printed in extenso, in view of Mr. Morrison's repudiation of certain of its facts? There was nothing really new. Mr. Bertram Blount said that aluminium was a so entrancing, indeed, almost pyrotechnic, subject, that the object of the paper had been overlooked. Its aim was mainly historical. For his own part he would summarize the history of aluminium as belonging, firstly, to the experimenter, and then to the academical chemist, whose work was equally notable for

its originality and its impracticability. There was no reason why the discussion should be confined to the aluminium furnace. There was that closely guarded secret—the phosphorous furnace. Did anyone know how phosphorous was prepared electrically? Returning to aluminium, Mr. Blount, after some further remarks, concluded by observing that the aluminium industry was now settled and lucrative, but there was still room for great scientific development.

Another speaker asked about the purposes for which calcium could be actually used. Prof. F. W. Harbord observed that he had had no practical experience of aluminium manufacture. Prof. Huntington (who was in the chair) appealed to the previous speaker for his opinion as to a metallurgist on the resultant effect of using calcium in place of aluminium in steel work, and received the reply that a similar effect could be expected. Only small traces would be necessary, otherwise the metal would be very spongy if cheaper calcium might be used, but at present only about 4 ounces of aluminium was required per ton.

I must defer until next month my account of the rest of the meeting, as my space is restricted.

MARKET QUOTATIONS DURING JANUARY.

During January prices have remained fairly steady, the closing prices for some of the typical commodities whose movements best serve to indicate the general trends of prices, being: Ammonia sulphate, £12.11.3 per ton; bleaching powder (35 per cent), £4.10 per ton; crude carbolic acid liquid (62½ per cent), 1s. 2d. per gallon; bicarbonate of soda, £6.15 per ton; caustic soda (77 per cent), £10.12.6 per ton; copper sulphate, £25 per ton, and zinc sulphate, £6.15 per ton.

In the metal market, the chief feature is a decline in Cleveland warrants to £2.12.4, and hematite to £3.9. In regard to these small declines, the general election has been in part responsible. There is still a heavy demand, and tariff reform being apparently relegated to the Greek Kalends, a source of apprehension and unsettlement has been removed. Tin has fluctuated rather wildly, reaching £167.10 by the middle of the month, falling to £162 in three days, then recovering and closing at £165.5, an uncomfortably high price. Copper closed at £78.12.6, not falling to less than £77.5 during the month. English lead closed at practically £17, a decline from the high price of £19, which was touched on Jan. 5.

London, Feb. 7.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

INDUSTRIAL ELECTROCHEMISTRY.

Bleaching Liquor by Electrolysis.—In our Vol. I., p. 439, a concise summary was given by W. H. Walker of the various processes and apparatus in use for the production of hypochlorite by electrolysis of sodium chloride in cells without diaphragm. Interesting results obtained with one of the apparatus described there, namely, the Hass & Oettel cell, in a New England textile mill, were given in a paper by H. S. Duckworth, before the New England section of the Society of Chemical Industry. The following table is given concerning the work of the cell:

Capacity of tank = 126 U. S. gallons = 477 litres.
Brine at 21½° Twaddell = 169 pounds salt = 76.66 kilos.

	Hours Worked					
	1	2	3	4	5	5½
Grams Cl per litre.....	4.65	7.90	10.44	12.58	13.91	14.38
Temperature °C.....	17	21	21	20	21	21
Amperes at 110 volts..	79	74	73	70	65	64
Horse-power hours....	11.7	22.6	33.4	43.7	53.3	58.0
Total Cl in grams.....	2,218	3,768	4,980	6,000	6,635	6,859
Salt per kilo. of Cl....	34	20.3	15.4	12.8	11.5	11.2

The following calculations of cost are made: The salt is valued at $6.10 per ton delivered. Thus 169 pounds of salt worked for 5½ hours give 6.859 kg. Cl = 15.12 pound. Three pounds of electrolytic chlorine are stated to do the work of 4 pounds of chlorine from bleaching powder, and, therefore, the 15.12 pound of active electrolytic chlorine is equal to about 60.48 pound of bleaching powder. The cost of the power is calculated first on the basis of water-power and then on the basis of steam-power. For water-power the horse-power-year is assumed to cost $15.00. The time of one run = to 5½ hours in the above table has been chosen, since it allows of two runs per day of 12 hours for five days in the week and one run on Saturday, which is in accordance with the usual hours of working of the textile industry in the East. The cost of the power is based on an assumption of 58 hours per week. The cost of steam-power is assumed to be $25.00 per horse-power year.

Under these assumptions the author gets the following comparative costs of the hypochlorite process and for the use of bleaching powder. First for water-power he gets in cents:

	Cents.
Cost salt	51.54
Cost power	27.84
Total	79.38
Cost of equivalent amount (60.48 pounds) bleaching powder at 1¼c. =	75.60
Freight on same	7.00
Total	82.60

Secondly for setam-power he gets—

Cost salt	51.54
Cost power	46.40
Total	97.94
Cost of equivalent amount (60.48 pounds) bleaching powder at 1¼c. =	75.60
Freight on same	7.00
Total	82.60

The author discusses the advantages of the electrolytic production of hypochlorite, and points out that the process is not only applicable to the whitening of cotton in any form, but is especially adapted to the bleaching of flax. It is also applicable to the fibres used in paper making, also to the bleaching of jute, oil, artificial silk, viscose compounds, etc. The process is also used largely in linen bleacheries in Germany, and the author recommends it strongly for laundries. The full paper and the discussion which followed, are published in the *Journal of the Society of Chemical Industry*, Nov. 30, 1905.

Dissolved Acetylene.—Two papers, by Kuchel and by E. Bournonville, read before the International Acetylene Association, are abstracted in the London *Engineer*, Oct. 20, 1905, and in *Science Abstracts* of Jan. 29. Acetylene is dissolved at a pressure of about 10 atmospheres in acetone, which is ab-

sorbed within some porous material held in steel cylinders. In America the porous material is made of a paste of asbestos in fine fibers and sodium silicate, moulded into discs fitting the steel cylinders, and dried at a gentle heat. In Austria the paste is made of charcoal and a cementing substance, run into the cylinders as a fluid, and then dried. Acetone expands as it dissolves the acetylene, and when saturated at 12 atmospheres, unit volume has become about 1.5 volumes. When the cylinder is charged to 12 atmospheres, according to Kuchel, the solution of acetylene in acetone expands till it fills 64.3 per cent of the space within the cylinder, 15.7 per cent being occupied by compressed gas, and the remaining 20 per cent by the porous material. The acetone vapor passes off and is burnt with the acetylene. In practice 1,000 litres of acetylene carry off the vapor of 0.06 litre of liquid acetone. This is no disadvantage; the acetone vapor burns well and is cheaper per unit volume than acetylene. Experiments have also been made with a view to finding the extent to which the pressure is raised by increased temperature. From these, it appears that if a cylinder is charged to a pressure of 12 atmospheres at a temperature of 20° C., it might develop a pressure of about 24 atmospheres if exposed to the hottest rays of the sun. A cylinder charged at 12 atmospheres will contain about 100 times its apparent volume of available acetylene. The papers of both authors close with figures relating to cost, particularly with a view to the lighting of railway carriages.

Ozone by Silent Discharges.—Before the last meeting of the American Phys. Society, A. W. Ewell described experiments on the electric production of ozone by silent discharges, using an alternating current and plate electrodes separated by dielectric. According to the *Phys. Review* of February, the chief results are as follows: The yield per coulomb was found quite independent of the dielectric, and greater the higher the gas velocity. The yield increases with the current to a maximum and then decreases. Narrow, bare electrodes are most efficient. The yield per kilowatt-hour is greatest for a polar distance of a few millimeters. This type of electrodes is far more efficient than the point and plate and than other minor types.

Ozone by Electrolysis of Alkali Fluorides.—A brief paper recently presented by E. B. R. Prideaux before the Faraday Society (and abstracted here from advance sheets) refers to the production of ozone from aqueous solutions of KF and of HF, due to the action of nascent fluorine on water. The electrolysis of potassium fluoride seems more promising commercially than that of hydrofluoric acid, since potassium fluoride solutions are both easier to deal with and do not lose strength so rapidly by evaporation and attack of the containing vessel as solutions of hydrofluoric acid. The author's experiments show, however, that the yield of ozone from saturated potassium fluoride solutions at 0° C. is in all cases quite low, certainly not exceeding 1 per cent.

Electrolytic Preparation of Spongy Tin.—In the *Comptes Rendus* of Jan. 8, D. Tommasi describes an industrial method of preparing spongy tin, and gives figures with regard to the efficiency of the method. The following notes are taken from the London *Electrician*, Jan. 26: "The electrolytic cell contains two anodes of tin, and the liquid consists of fifty parts water, ten parts stannous chloride and one part hydrochloric acid. The cathode is a large copper disc, capable of rotating in a vertical plane, and fixed for this purpose with its center to a bronze shaft. The disc is half submerged in the liquid. The upper half passes between two brass scrapers, which scrape off the tin deposit and depolarize the disc. The spongy tin is collected automatically and washed, the liquid being evaporated to the concentration of the bath and used over again. In one experiment, with a disc 30 cm. in diameter, an e. m. f. of 3 volts and a power of 120 watts, the amount of tin deposited per horse-power-hour was 380 grams, the theoretical amount being 440 grams. The efficiency is therefore 86 per cent. But there is no reason why discs as large as 3 meters in diameter should not be used. With a disc of that size the amount of tin deposited would be 4,400 grams per horse-power-hour, or 105 kg. per day of 24 hours."

METALLURGY.

COPPER.

Losses in Bessemerizing Matte.—Dr. E. Günther, in *Metallurgie* for Nov. 22, discusses the German patent 160,046, of Oct. 5, 1904, which contemplates stopping the Bessemerizing of matte when all the iron is slagged, and using the copper sulphide as anode in electrolytic refining vats, thus avoiding the losses of copper, silver, etc., occurring in the blowing to blister copper. Dr. Günther thought it timely to find what the losses of copper and silver are in this second half of the Bessemerizing, and to this end run a small converter in the laboratory of the Aachen Technical School. The lining was an aluminious sand brick, air pressures up to 350 mm. of mercury, temperatures determined by the Wanner optical pyrometer, time of blow to rich matte 25 to 30 minutes, to blister copper 45 to 50 minutes, temperatures in the first case 1,150° to 1,200°, in the second 1,250° to 1,280°. With a matte carrying 36.72 per cent copper, 0.1913 per cent silver, 2.78 per cent of silver, blown up to 71.15 per cent copper, the losses were 1.77 per cent of the copper and 2.78 per cent of the silver present; blowing the same matte to blister copper, the losses in fume were 20.14 per cent of the copper and 22.12 per cent of the silver present. Using a richer matte, carrying 46.42 per cent copper and 0.2443 per cent silver, the losses, when blowing it up to 77.06 per cent matte were 0.37 per cent of the copper and 1.59 per cent of the silver; but when blowing it to blister copper 21.11 per cent of the copper and 23.42 per cent of the silver.

These results prove the extraordinary large losses by volatilization occurring in the second stage of the Bessemerizing operation, and show that if it is possible to blow to rich matte and then to electrolytically treat it, these high losses can be avoided. The patentees of the German patent have, therefore, the correct idea of where great saving may be made, whether or not they have found the successful and specific remedy.

Bessemerizing Matte.—F. W. Hinrichsen and T. Watanabe made some very interesting experiments in Dr. Borchers' laboratory, at Aachen, on blowing matte with air containing above the normal proportion of oxygen. Their results are reported in *Metallurgie* for July 8. Using a small experimental converter, preheated by a blast flame, 25 kilograms of matte was blown in 35 to 39 minutes, using ordinary air, with a rise of temperature of 180° to 250° for low-grade matte and 15° to 70° for high-grade matte. When exactly similar amounts of the same mattes were blown with air containing 28.5 to 29.0 per cent of oxygen, the blows lasted 16 to 21 minutes, with rises of temperature of 335° to 390° for low-grade matte, and 85° to 105° for high-grade matte. The difficulties of blowing rich matte to blister copper are by this device largely reduced, and calculations are made as to a possible commercial application, but the present price of oxygen seems to still stand in the way. An important point in favor of running in this manner is that silica sand charged with the matte was melted down by the higher temperature to a homogeneous slag, thus saving corrosion of the lining to a considerable extent; a reaction which has been always found impracticable when blowing with ordinary air.

Copper and Arsenic.—The Königlich Sächische Bergakademie, at Freiberg, has recently, under the direction of Prof. K. Friedrich, taken up actively the subject of metallography, and a very comprehensive article on the copper-arsenic compounds may be regarded as the first fruits of this activity. The eighteen large pages which it occupies in *Metallurgie* for Oct. 22 are worthily filled, and the article is sure to attract attention from all directions. The twenty tests made were approximately every 2 per cent from pure copper to 56 per cent

copper. It was found impracticable to make a richer alloy than 44 per cent arsenic. The melting point curve falls with great regularity at the nearly constant rate of 18° for each per cent of arsenic, to the eutectic containing 21.5 per cent of arsenic, and melting at 682°. Rising sharply, the melting point rises at the rate of 19° per cent of arsenic to a maximum of 830° for the compound Cu^3As, containing 70.88 per cent of copper. Thence up to 44 per cent of arsenic the melting point again fell almost linearly, at the rate of 14° for each per cent of arsenic, to 651°. Within the range studied there is, therefore, only one true chemical compound, Cu^3As, and one eutectic at 21.5 per cent arsenic. Two other eutectics, however, were indicated by halts in the cooling curve after setting had taken place, one at 711°, corresponding to a transformation of the alloy containing 33 per cent arsenic, and another at 600°, corresponding to a possible eutectic at 48 per cent arsenic. Another halt, at 305°, found in alloys with 32 to 44 per cent arsenic, corresponds to some transformation in the solid alloy, the nature of which is unknown. The progressive constitution, starting with pure copper, is therefore,

	Per Cent As	*Melting Point.*
Cu	0	1084
Cu + eutectic of Cu and Cu^3As		
Eutectic of Cu and Cu^3As	21.5	682
Cu^3As + eutectic of Cu and Cu^3As		
Cu^3As	29.1	830
Cu^3As and Cu^5As^2 (isomorphous mixtures).		
Cu^5As^2	32.0	822
Cu^5As^2 + eutectic of Cu^6As^2 and Cu_xAs_y		
Eutectic of Cu^5As^2 and Cu_xAs_y (48 per cent arsenic)	48.0	600

Twenty-three fine photomicrographs accompany and illustrate the paper, and prove the conclusions from the cooling curves. The minerals, Cu^6As (Algodonite) and Cu^9As (Whitneyite) do not form, and their existence as compounds is doubtful. The mineral *Ledouxite*, identified by Richards, corresponds very closely to the first eutectic. The alloys with arsenic are comparatively feeble; those containing much arsenic lose some by heating a long time, powdered, at 300° C.; even Cu^3As is not fixed at a red heat, as is known also from the Plattner slagging test for cobalt, nickel and copper when combined with arsenic, in which copper is known to stay as Cu^3As as long as Ni^2As is present, but to lose some arsenic as soon as all the nickel is removed.

LEAD.

Treatment of Galena.—Carmichael's British patent, 17,580, of Jan. 30, 1902, states that a mixture of PbS and $CaSO^4$ react at a low red heat, about 400° C., to form $PbSO^4$ and CaS. F. O. Doeltz considered the reaction to be *a priori* unlikely, and therefore made some very decisive laboratory tests, which settled the question. The results are reported in *Metallurgie* for October 8, and will interest all concerned with the treatment of lead ores. An intimate mixture of PbS and $CaSO^4$ was kept 1.5 hours at 400° C., in a current of CO^2, but no trace of reaction was to be detected. Heated to 850° for 1 hour a considerable amount of PbS distilled off into the cooler part of the tube, condensing there unaltered, but no change, even a microscopic one, could be detected in the mixture. By heating above the melting point of PbS (which is 930° to 940° C.) the mass was melted down at 1,100°, but still did not react. These results were completely substantiated by heating together an intimate mixture of $PbSO^4$ and CaS. Even at 400° this mixture turns gray from formation of PbS. $PbSO^4$ and Na^2S react on each other even cold when ground together in a mortar, and $PbSO^4$ and CaS show evidences of the same. From these tests the author concludes that Carmichel's process is based upon a wholly suppositious reaction, which, in fact, works only in the reverse direction to what is desired.

Lead and Galena.—Prof. Friedrich, of the Freiberg Bergakademie, and his assistant, A. Leroux, publish in *Metallurgie* for Nov 22, a timely and very much needed study of the relations of PbS to Pb. They prepared nineteen mixtures of these two substances in different proportions from pure lead to pure PbS (13.5 per cent sulphur), and studied the mixture as if it were an alloy of Pb and PbS. The melting point of PbS was determined as 1,103° C. (2,003° F.), the first 10 per cent of lead reduced the melting point 30°, but subsequent additions very little, 75 per cent lead to 25 per cent of sulphide still melting at 1,000°. From this point the melting points fell off more quickly, being for 80 per cent of lead 950, 85 per cent 930, 90 per cent 880, and 95 per cent 806. It thus appears that the first 5 per cent of PbS present, equal to only 0.67 per cent of sulphur, raises the beginning of the setting point of lead 480°. This is one immensely important fact for lead smelters; another is that the two substances melt together in all proportions, showing a perfectly uniform transition, in the molten state, from Pb to PbS, with every proportion of sulphur from 0 to 13.5; a third is that no sign of any such compounds as Pb^2S, or Pb^4S, could be detached. The solution characteristic of the mixture was the fact that every mixture tested showed the presence of lead in it by a halt in the cooling curve at 327°. The photomicrographs confirm these conclusions, by showing a regular gradation from lead with scattered crystals of PbS to pure PbS.

MERCURY.

Roasting of Ore.—Several Western papers (*Mining Reporter, Mining World, Pacific Miner*) have recently contained rather roseate descriptions of the new Dennis furnace, used at the Black Butte Mines, Lane County, Oregon; but if half what is claimed for the furnace is true, it is a great improvement on the best modern mercury furnace—the Scott-Huttner. It is stated that patents are pending, and for this reason detailed descriptions cannot yet be given. We are told, however, that the coal is first gasified, and then the ore heated by combustion of the gas, thus avoiding ash and soot in the gases; also that the ore is dried in one chamber, heated to about 200° C. (400° F.), then passes into a second compartment heated to 300° C. (600° F), then to a third, and finally to a fourth, heated to 800° to 900° C. (1,400° — 1,600° F.). The ore passes through the furnace in 4 hours (instead of 24), the capacity is 240 tons daily (against 40 tons), and the condensers are kept free from ore dust and soot, so that the mercury condenses clear. We will present to our readers as soon as it can be gotten an official report of the achievements of this Western wonder.

ZINC.

Review.—In *Glueckauf* of Dec. 2, 9, 16, 1905, F. Peters gives a concise summary of actual developments and tentative proposals which have been made since 1901 on use of electrochemical methods in the metallurgy of zinc. The summary does not seem to give much that is new, but should be useful for the many references which it contains. The author discusses electrolysis with aqueous solutions, with fused electrolytes and electric furnace methods.

Zinc Shavings.—London "Engineering" of Nov. 17 contains drawings and illustrations of a lathe specially designed for the manufacture of zinc shavings.

IRON AND STEEL.

Blast Furnace Practice.—A very interesting note for blast furnace managers and students of blast furnace running, is that of E. de Loisy, in the *Revue de Metallurgie* for November. This engineer had charge, for two years, of a blast furnace north of the Urals, in 60° north latitude, where in Summer the temperature marked 40° to 45° C. (104° to 113° F.) in the shade, and in winter, once for two consecutive days, stood at — 51° C. (— 60° F.). Under such conditions, with the blowing engine running the same speed, the weight of air (and

consequently of oxygen) blown into the furnace per unit of time was inversely as the absolute temperatures, viz.:

$$\frac{45 + 273}{-51 + 273} = \frac{318}{222} = 1.43 \text{ to } 1.00$$

or 43 per cent more oxygen was blown in, in the coldest weather than in the hottest. Unfortunately, Monsieur de Loisy does not point the moral to adorn his tale, by telling whether the furnace really ran anything like that much faster in the cold weather. Undoubtedly it did, however, make much more iron in the Winter; and this recalls the predictions made when hot blast was first introduced, which were to the effect that since a furnace made more iron in cold weather, when it was fed with cold air, than it did in summer when it was fed with warm air, that, therefore, heating the blast must result in lessening the production of the furnace.

Fusibility of Blast Furnace Slags.—O. Boudouard, an assistant of Prof. Le Chatelier, published in *Revue de Metallurgie* for June, 1905, an exhaustive account of his laboratory researches on this subject. The same material was incorporated in a paper read later before the Iron and Steel Institute. A great deal of careful work was done, but the experimenter made the capital mistake of determining the temperature by Seger cones, thus removing from the outset the possibility of scientifically reliable temperatures being obtained; for, no matter how careful the calibration of the cones, the conditions under which they were calibrated can never be exactly reproduced during an experiment—leaving out of consideration the exactness of the comparison with the cone of substance being tested. It is, therefore, probable that the temperatures given in the paper are throughout unreliable. One conclusion is that when the ingredients of the slag are finely ground and intimately mixed, the temperature of formation of the slag is practically identical with its melting point; but although this may be so, it must be borne in mind that in a blast furnace the slag-forming ingredients are neither finely ground nor intimately mixed, so that, in practice, the temperature at which a slag forms is almost inevitably far above its melting point.

Hardening and Tempering.—Demozay, in *Revue de Metallurgie* for October, records some illuminating tests made on tempering. He measured the tempering by the resulting hardness, as given by the Brinell steel-ball test. Taking a piece of hardened steel, it was found that equal degrees of tempering were produced by heating 5 minutes at 775°, 10 minutes at 766°, 15 minutes at 755°, 20 minutes at 745°, or 25 minutes at 735°; while at 730° no tempering took place in over 30 minutes heating. For this piece of steel, heated between 775° and 735°, each extra 2° of temperature above 735° compensated for 1 minute shorter time of heating. From this series of tests the author concludes that if the temperature of transformation is *a*, it is better to heat the sample to a higher temperature than this, in order to cause the transformations to take place quickly, then to cool down to the temperature *a* and to then temper. By proceeding thus, the steel has ample time and opportunity to be transformed; the latter operation not being an instantaneous change at *a*, but a change which takes considerable time at that temperature but a shorter time at a higher temperature. Records of many series of tests are then given, using pieces of different sizes, heated at different rates and cooled at different rates in different menstrua. The following important conclusions are given in the words of the author himself:

HEATING.

A.—The transformation point of a steel varies in practice between two extremes; the maximum being the temperature of transformation, measured at the center of a very small sample heated rapidly to a high temperature; the minimum being that of the periphery of a large specimen heated very slowly to a lower temperature.

B.—(*a*) To heat a piece of steel rapidly to a given temperature it is advantageous to have continuously the greatest possible difference of temperature between the piece and its surroundings. This advantage is greater the larger the piece.

(*b*) The time required to heat a piece increases in much greater proportion than the size of the piece.

C.—Aside from the size of the piece being heated, and all other factors being constant, as the temperature of the heating bath increases.

(*a*) The maximum speed of heating increases proportionately.

(*b*) The transformation effect becomes evident sooner.

(*c*) The temperature of commencement of the transformation decreases, that of the middle point and end of the transformation increase.

(*d*) The range of temperature covered by the transformation increases.

(*e*) The total duration of the transformation period decreases.

(*f*) When the transformation is once provoked it will progress at the same temperature, and if the rate of heating is changed at this time, it appears to influence only the time necessary for the transformation.

D.—For a given temperature of the heating bath, at points at regular intervals between the outside and the center of the piece, as the center is approached.

(*a*) The maximum speed of heating decreases.

(*b*) The commencement of the transformation is retarded more and more.

(*c*) The temperature of beginning of transformation rises.

(*d*) The duration of the transformation increases.

(*e*) Between any two given points the difference between the temperatures of commencement and end of the transformation increases with the temperature of the bath.

E.—At homologous points of similar pieces the temperature of the bath being alike.

(*a*) The temperature of the transformation varies inversely as the size of the piece.

(*b*) The duration of the transformation period varies directly as the size of the piece.

(*c*) The duration of the transformation period varies inversely as the range of temperature embraced in that change, independently of the size of the piece.

(*d*) The product of a linear dimension of the piece by the maximum velocity of heating varies proportionately to the temperature of the bath.

COOLING.

A.—The transformation point during cooling of a steel varies between two extreme temperatures; the maximum is that of the transformation of a point on the periphery of a large specimen cooled very slowly; the minimum is that of the transformation of the center of a small specimen cooled very slowly.

B.—(*a*) The maximum temperature attained during the heating conditions the maximum possible rate of cooling, which is proportional to this temperature.

(*b*) All other factors being equal, the energy for tempering bath may be represented by the value of the ratio between the maximum rate of cooling of any two baths.

C.—The fall of temperature during tempering commences to produce effects in a time which is shorter as:

(*a*) The speed of cooling is increased.

(*b*) The smaller the specimen.

D.—The temperature of transformation when cooling depends both on the speed of the cooling and the duration of the heating after the transformation point was passed going upwards. All other things being equal the transformation point when cooling will be lower as:

(*a*) The speed of cooling is greater.

(*b*) The duration of heating has been prolonged.

(*c*) A given variation, the maximum speed of cooling displaces the transformation the more the shorter the time of heating.

E.—With the same tempering bath and at homologous points of similar pieces.

(*a*) The maximum speed of cooling decreases as the dimensions increase.

(*b*) The temperature of transformation increases with the size of the piece.

F.—All other things equal, the hardness at any point varies with the mean velocity of cooling at the period of transformation.

(*a*) This velocity varies in the same manner as the maximum velocity of cooling, but diminishes much more quickly.

(*b*) With a given tempering bath this velocity varies inversely as the size of the piece.

(*c*) For a given hardness, other factors being equal, the time during which a piece should be held at a given temperature varies inversely as the temperature.

G.—For a given heating temperature and tempering bath, at points equally spaced from periphery to center.

(*a*) The maximum speed of cooling decreases.

(*b*) The speed of cooling during the transformation falls still more rapidly.

(*c*) The transformation is more and more delayed.

(*d*) The temperature of transformation decreases.

(*e*) The period of transformation lasts longer.

Nickel-Alloy Steels.—The seventh report of the Alloys Research Committee of the (British) Institute of Mechanical Engineers deals with the effect of varying percentages of nickel in steels containing about 0.45 per cent carbon and 0.9 per cent manganese. The contents of carbon and manganese were maintained constant, while the nickel was varied. From the report, which is signed by Carpenter, Hadfield and Longmuir, the following points, among many others, are especially interesting. With the increase in nickel content up to 4 per cent, the change in properties of forged bars is gradual; the material, when under elastic stress yields more to the stress; at the same time, after the apparent yield point is passed, the maximum stress increases. Although the change in properties is gradual, there is in nearly every case a more or less pronounced kick in the curves between 0 and 4 per cent nickel. At some point between the percentages of 4.25 and 4.95 nickel, there is a very sudden change in nearly all of the properties, evidenced by a rapid increase of maximum stress, which reaches the highest value at 6.42 nickel, a fall of ductility, and an increase of brittleness, as shown by the bending, tension, torsion and shock tests. Thus, as far as industrial products are concerned, a danger limit for nickel content is found at 4.25 per cent, when carbon and manganese are present to the extent of 0.44 per cent and 0.88 per cent, respectively. The results of the tests of the cast material followed generally the same order as those of the forged material, the maximum tensile strength corresponding to a content of 7.95 per cent nickel. It is peculiar that this maximum is associated with an elongation of 4.5 per cent, and the three steels which in the forged condition are distinctly brittle, show in the cast-normalized state elongations of 6.2 per cent, 4.5 per cent and 6.2 per cent. Tests made at the temperature of liquid air show that these alloys are well adapted to be used at low temperatures. In every case the tenacity is greater at the low temperature than at ordinary temperatures. The alloy containing 20 per cent of nickel has at ordinary temperatures a tensile strength of 43.9 tons per square inch, which at the temperature of liquid air—182° C.—rises to the remarkable figure of 157.2 tons, with an elongation of 15.5 per cent.

Nickel-Manganese Steels.—Guillet, in *Revue de Metallurgie* for November, discusses very instructively the limiting proportions of nickel, manganese and carbon found in these steels, and the essential nature of the alloys. Steels were studied with 0.15 per cent carbon, 5, 7 and 15 per cent of manganese, and 2, 12 and 30 per cent of nickel; also harder steels with 0.75 carbon, and similar quantities of manganese and nickel. From an extended mechanical and micrographic study of these eighteen steels, together with some ten other specimens outside those limits, the author concludes that there are three varieties of these steels, corresponding to the values of the following equations:

$$\frac{\text{per cent nickel}}{13} + \frac{\text{per cent manganese}}{6} + \frac{\text{per cent carbon}}{1.65} = P$$

$$\frac{\text{per cent nickel}}{21} + \frac{\text{per cent manganese}}{13.5} + \frac{\text{per cent carbon}}{1.65} = P^1$$

If P is less than O, the steel is a perlitic steel

If P is greater than O and P^1 is less than O } the steel is martensitic.

If P^1 is greater than O, the steel contains *gamma* iron.

The above explains the microscopic appearance and some of the consequent thermal and mechanical qualities. These martensitic steels can in many cases replace nickel steels, with the advantage of being much cheaper.

Chromium Steel.—The engineer for Jacob Holtzer & Co., Mr. A. Brustlein, relates in *Revue de Metallurgie* for July last, how he commenced to make chromium steel in 1874. By mixing powdered potassium bi-chromate, wood-charcoal, ground glass and fine steel turnings, and melting down in a crucible, he obtained ingots of ferro-chromium containing about 55 per cent of chromium. To make this more cheaply, recourse was had later to the natural chromite, which was pulverized, made into a soup with bran and powdered charcoal, and then boiled down to a dry mixture. The mass was mixed with more charcoal powder, ground glass and a little lime, ground to a uniform tint, and then charged into old crucibles which were unfit for further manufacture of steel. Giving these crucibles a very strong heat, which frequently softened their upper parts completely, there was obtained from each an ingot weighing 1 to 2 kilograms, containing about 55 per cent of chromium, and which cost about 2 francs (40 cents) per kilogram of contained chromium. Ferrochromium was thus made for a dozen years, but later the steel works of St. Chamond succeeded, at their works at Broucau, in making regularly a product rich in chromium in a cupola, at a lower price, and the manufacture in crucibles was abandoned.

Influence of Nitrogen on Iron and Steel.—Hjalmar Braune, in *Revue de Metallurgie*, Vol. II., No. 7, describes some very important results obtained by heating iron and steel to 800° in ammonia gas, for various lengths of time, and analyzing and making microscopic study of the specimens. Tests were made on soft iron with 0.06 per cent of carbon, medium steel with 0.5 per cent carbon, and hard steel with 1.15 per cent of carbon. The soft iron increased regularly in tenacity, but decreased in elongation, the results being:

Per Cent Nitrogen.	*Elongation.*	*Tensile Strength (K. per sq. m.m.)*
0.000	39.0	33.5
0.015	34.0	34.0
0.030	32.0	35.1
0.045	30.0	36.0
0.060	29.5	36.8
0.075	28.2	37.5
0.090	27.0	38.0
0.105	24.0	38.4
0.120	18.0	38.8

The effect on steel is still more marked, malleability disappearing when the contents of nitrogen are the following:

Steel with 0.20 per cent carbon ..... 0.050 to 0.060 per cent.
Steel with 0.50 per cent carbon ..... 0.040 to 0.045 "
Steel with 1.15 per cent carbon ..... 0.030 to 0.035 "

The nitrogen seems to dissolve in the ferrite or pure iron

present, imparting to it a characteristic striated appearance under the microscope. The iron is saturated when it contains 0.20 per cent nitrogen, and then shows little rods or spikes on the polished section and is very brittle. However, commercial metal rarely contains 0.06 per cent, but amounts of 0.030 to 0.040 are frequent, and frequently account for the unexpected brittleness of high carbon steels. Direct contact with air does not favor the entrance of nitrogen into the steel, unless a basic slag and a reducing atmosphere are present. Such conditions are found in a blast furnace and during recarburization in a basic Bessemer converter.

The observations of Mr. Braune are clearly presented, and if confirmed by other reliable observers will do much to clear up some of the so-called "*mysteries*" of steel.

Electric Conductivity of Steel.—In view of the increasing use of the "third rail" as a means of conducting electric power to moving cars, the problem of the effect of chemical composition and physical treatment on the electric conductivity of steel is of importance. Some experiments made in this line by S. S. Wales are described in the December issue of the "Rose Technic." It appears that the electrical resistance increases with the total amount of dissolved impurities, or what is known as the "total content not Fe." Of all the elements contained in steel, manganese has the most powerful effect in increasing the electric resistance.

Strength of Steel at Different Temperatures.—The Swedish metallurgist, Brinell, has determined (*Iron and Steel Magazine*) the strength of acid and basic open-hearth steel at temperatures up to 1200° C. The chemical composition of the two specimens was nearly identical (carbon 0.17, silicon 0.014, manganese 0.35, sulphur 0.015, phosphorus 0.028 in acid steel and 0.009 in basic). The results were:

Temperature		*Strength in Kilos.*	*Strength in Lbs.*
C°	*F°*	*Per Sq. Millimeter.*	*Per Sq. Inch.*
0°	32	35.8	51,100
100°	212	35.8	51,100
200°	392	34.4	49,100
300°	572	42.2	60,300
400°	752	41.1	58,700
500°	932	39.5	56,400
600°	1112	26.9	38,400
700°	1292	13.8	19,700
800°	1472	9.8	14,000
900°	1652	8.4	13,400
1000°	1832	6.7	9,600
1100°	2012	4.6	6,600
1200°	2192	2.7	3,900

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Electric Tube Furnace.—J. E. Ober, 812,801, Feb. 13 (assigned to General Electric Co.). Application filed July 15, 1904.

The essential feature is the covering of the heating tube of carbon with a uniform layer of titanium carbide to prevent deterioration of the tube. The construction is shown in Fig. 1, where 1 are massive end pieces of carbon or graphite, and 2 is the tube. The latter comprises two cylindrical portions 3 and an intermediate concentric cylindrical portion 4, the external diameter of which is less than that of the end portion. A uniform layer 5 of titanium carbide surrounds the portion 4. The whole is embedded in coke. As soon as current passes through the tube 2, the surrounding layer of powdered titanium carbide sinters together, to form a shell of considerable mechanical strength. This shell is a good conductor of electricity and is non-hygroscopic and is refractory.

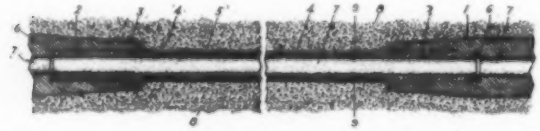


FIG. 1.—TUBE FURNACE.

Electrolytic Processes.

Platinum Plating with Alternating Current.—W. C. Arsem, 811,759, Feb. 6 (assigned to General Electric Co.). Application filed July 25, 1904.

In most cases electrolysis of a metallic salt solution with an alternating current results in the deposition of the metal during one-half cycle on one electrode (while it is cathode), and the passing back into solution during the next half cycle from the same electrode (which is now anode). The total net result is, therefore, zero. But this will not be the case with certain metals which are not easily corroded by the acid radical of the plating bath. In such cases both electrodes will be plated with the metal. The inventor uses this application of alternating current for plating purposes, for depositing heavy coatings of platinum on copper, iron or other metallic plates. As electrolyte he uses a solution of ammonium chloroplatinate in sodium citrate.

Production of Hydrated Oxide of Lead.—J. H. Bridge and C. Ellis, 811,552, Feb. 6. Application filed March 14, 1904.

An electrolyte of sodium chloride of 10° Baume is used with lead as anode and an inert cathode of graphite, platinum or lead. The anode should be of a good quality of lead, quite free from iron; ordinary pig-lead is usually suitable. The electrolyte is heated to prevent the precipitation of lead chloride during electrolysis. An anodic current density of 20 amps. per square foot is used. The anodic reaction is the formation of lead chloride, which passes into the hot electrolyte and reacts with the sodium hydroxide formed at the cathode, giving hydrated lead oxide (which appears as a white precipitate on the bottom of the cell) and regenerating sodium chloride. The electrolyte is, therefore, continually regenerated.

Anode.—L. Levett, 813,048, Feb. 20. Application filed May 9, 1905.

The object is to provide an anode for electroplating which may be entirely submerged in the electrolyte, and which will always present a smooth surface, so that any oxide which forms on it may be readily scraped off. The construction is shown in Fig. 2, both in perspective view and in vertical cross-section. The anode consists of an in-

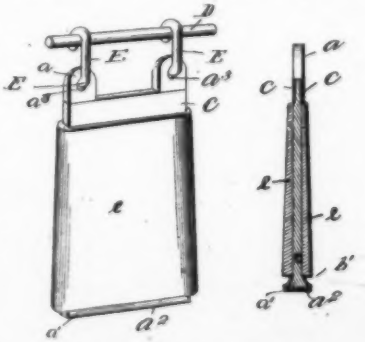


FIG. 2.—ELECTROPLATING ANODE.

ner carbon plate or core *c*, with the ears *aa* for suspension, and an outer sheath *e* of metal which may be readily slipped on or off the carbon plate. The lower enlarged portion of the carbon plate is covered with insulation a^2.

Wired Plating and Dipping Rack.—J. P. Clark, 811,375, Jan. 30. Application filed June 26, 1905.

To a vertical wooden center bar a series of transverse wooden bars are rigidly secured. To each of these transverse bars are attached a series of metallic wire hooks, from which the articles to be plated are suspended. These wire hooks are electrically connected to wires placed in longitudinal grooves in the transverse bars, and these wires are again in electrical connection with a wire placed in a groove in the vertical center bar and connected with the outside terminal.

Electrolysis of Water.—W. F. M. McCarty, 813,105, Feb. 20. Application filed Nov. 8, 1904.

The object is "to render the water, which is normally not an electrolyte (!), more susceptible to the action of an electric current by adding to the water a substance which will disturb or break up the molecular arrangement of the hydrogen and oxygen of the water, and thus facilitate its ready decomposition." For this purpose the inventor adds metallic sodium (!), resulting in formation of sodium hydroxide and evolution of hydrogen. "At the moment of ebullition" he supplies current to the electrodes.

BATTERIES.

Storage Battery.—William Fennell and William P. Perry, 810,929, Jan. 30. Application filed March 17, 1904.

The third claim reads: "In electric accumulators a honeycombed mass, an active material on the exposed surfaces of the mass, and unobstructed passageways formed therein, besides the interstices of the mass, certain of said passageways being inclined for the egress of gas."

Storage Battery.—William Fennell and William P. Perry, 810,930, Jan. 30. Application filed March 6, 1905.

A hard, porous, non-conducting substance, insoluble in the electrolyte, is used in the shape of a network, honeycomb or framework, so as to contain the electrolyte in the plate itself, and at the same time to act as a support for the active material which is spread over the surface in the form of a thin film. Pumice is the most effective material for the honeycomb, but earthenware or other burnt clay, asbestos, slate, soapstone or the like may also be used. One special construction consists of a number of rough burnt-clay rods of irregular shape, each covered with a film of active matter, and held together in a bundle by india rubber rings, yarn or the like. A piece of metallic wire is placed in the center of the bundle to serve as conductor.

End-Cell Switch.—L. Lyndon, 810,958, Jan. 30 (assigned to General Storage Battery Co.). Application filed Oct. 17, 1904.

The object is to make the operation of the end-cell switch automatic. Thus the end-cell-charging switch will automatically set the contact brush of the switch upon such a cell contact that all the cells on one side of the contact are fully charged, while all on the other side have not yet been brought to full charge. The switch-actuating device is of electrical nature, and is controlled by the voltage of one or more of the end-cells, as is described in great detail in the specification.

Primary Battery.—C. E. Lockwood and G. A. Lutz, 812,504, Feb. 13. Application filed July 13, 1904.

Claim 1 reads: "A battery element comprising a perforated retainer containing a depolarizer and having a binder soluble in a battery liquid or solution for preventing such depolarizer from passing through the perforations in the retainer." The object is to replace a retainer when its depolarizer has been used up by a new retainer with fresh depolarizer. The arrangement appears to be intended specially for use of cupric oxide as depolarizer in an alkaline cell with sugar or similar saccharine matter as binder.

Primary Battery.—C. E. Lockwood and G. A. Lutz, 812,505, Feb. 13. Application filed July 13, 1904.

Compare the preceding patent. Claim 1 reads: "A battery element comprising a perforated retainer containing a depolarizer and having a binder soluble in a battery liquid or solution applied to the wall of the retainer closing the perforations therein to prevent such depolarizer from passing through the perforations in the retainer; said binder being of a character to not materially affect the electrical efficiency of the battery."

Binding Post.—E. C. Henn, 813,093, Feb. 20. Application filed May 9, 1905.

Details of construction of a binding post of a galvanic cell. Claim 1 reads: "An element for an electric battery-cell consisting of a rod of non-metallic substance having a bore in its outer end portion, a binding-post comprising conductor-attaching means at one end, and having at its other end portion longitudinally-extending ribs, said ribbed portion of the binding-post being inserted in said bore in the rod, the bore being of a diameter less than that of the engaging portion of the binding-post, whereby the ribs will have a retaining engagement with the wall of the bore."

MISCELLANEOUS.

Ozone Generator.—C. F. Birtman, 811,364, Jan. 30. Application filed June 9, 1905.

Mechanical details of construction of a chamber for producing ozone by silent discharges through air. The chamber contains vertical glass plates which act as dielectrics and form passages for the flow of air. On each side of such a glass plate there are two other glass plates, around which coils of wire are wound. These coils are alternately connected to the positive and to the negative terminal of the electrical supply.

RECENT METALLURGICAL PATENTS.

IRON AND STEEL.

Reduction of Iron Ore with Water-Gas.—G. M. Westman (812,247, Feb. 13) emphasizes that if iron ore is to be reduced by gases containing carbon monoxide and hydrogen, the gas should be free from oxidizing agents (like carbonic acid), and should be used at a temperature of about 1,100° C. The gas is produced as follows: Water is sprayed into a current of air, which is afterward raised to a temperature which must be at least high enough to convert the water into steam, and should be in practice "as high as possible." It is desirable to introduce into the air as large a proportion of water as possible; but the proportion of air must be high enough to maintain the gases at a proper reducing temperature, which for iron ore is 1,100° C. The mixture of air and steam is then brought into contact with a mass of glowing coke, which yields hydrogen and carbon monoxide. The gas is kept long enough in contact with the glowing coke until any carbonic acid which may be formed takes up enough carbon to form carbon monoxide. The gas is then introduced into the reducing furnace containing the ore mixed with a small quantity of solid carbon, the ore and carbon being preferably formed into briquets. The use of this small percentage of carbon in reducing the ore is to practically remove all traces of oxygen from the ore. But the amount of carbon must be small, only about 2 or 3 per cent, because the object of the process is to produce wrought-iron. If the producer gas contains sulphur (from the coke) this is removed by mixing limestone with the coke in the chambers of the gas producer. The process "can be carried on at a low cost and is of high efficiency. Furthermore, ore which cannot be reduced in ordinary blast furnaces, because it contains

titanic acid, can be reduced by this process. This process can also be advantageously used in reducing ores containing phosphoric acid. In blast furnaces, on account of the high temperature, the phosphoric acid is converted into phosphorus, which enters the iron. At the comparatively low temperatures employed in this process, however, the phosphoric acid is only slightly reduced, so that the resulting iron contains but little phosphorus."

Manufacturing Iron Sponge.—G. Gröndal (812,174, Feb. 6) patents a furnace for the production of iron sponge from pulverized iron ore and coal, the necessary heat being obtained by feeding a mixture of combustible gas and air in a number of streams repeatedly through the charge. For this purpose the furnace is provided with a large number of tubes arranged in zigzag across the shaft. To cool the produced iron sponge, the inventor uses either the combustible gas or the atmospheric air, which, when introduced into the furnace, is forced through passages to and fro until the iron sponge is sufficiently cooled to be discharged in a closed chamber connected with a supply of an indifferent or reducing gas, which is absorbed by the iron sponge, so that the latter is thereby rendered indifferent to the oxidizing action of the air.

Titanium Steel.—F. E. Canda (813,278, Feb. 20) calls attention to the difficulty of introducing titanium into steel. He has found that when ferro-titanium, containing 20 or more per cent of titanium, is introduced into molten steel, it is not melted and does not combine appreciably with the steel, but remains substantially unchanged. The difficulty is due to the fact that the temperatures available in ordinary metallurgical furnaces are below the melting point of high percentage ferro-titanium. Canda, therefore, melts the ferro-titanium in a small special electric furnace and mixes the molten alloy with the molten steel while the latter is run into the ladle.

Zinc.

Charging Machine.—In connection with the report of the visit of the American Institute of Mining Engineers to the Hazard works of the New Jersey Zinc Co., an account of which will be found elsewhere in this issue, three patents,

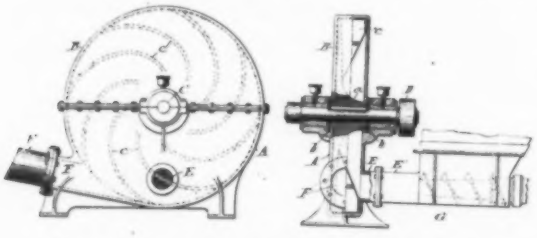


FIG. 1.—CHARGING MACHINE FOR ZINC RETORTS.

which have just been granted to A. L. J. Queneau (813,021, 813,022, 813,023, Feb. 20) are interesting. The first two patents refer to the method and apparatus for charging a retort or muffle. The construction of it may bee seen from Fig. 1, showing a side elevation and front elevation. The charge is fed from a supply-hopper, and by means of a feed-screw *G* through the feed-inlet *E* into the casing *A*. Upon the shaft *C* in this casing is kept the impeller disc, consisting of a single casting having a hub portion *a* with end flanges *b*, a flat main-body portion, constituting a circular plate of a diameter corresponding to the internal diameter of the casing, and a series of blades *c* of a curvature indicated in the left-hand diagram. At their outer ends these blades *c* are of a width corresponding to the width of the casing, and they continue of this width to a radial distance corresponding to the lower portion of the feed-inlet *E*, from which point they decrease in width until they merge into the surface of the disc. The charge forced into the casing through *E* will, therefore, receive the full impact blow of the extreme outer portion of the blade approaching at that particular instant. This impact blow is sufficient to give the charge a very considerable momentum and force it through the outlet spot *F* in a substantially cylindrical stream, which retains its shape and form without material deviation for a distance varying from 3 to 10 feet and more according to the velocity of movement of the impact blades. This practically solid stream may, therefore, be directed with great accuracy into the muffle. Patent 813,023 refers to a charging machine for charging a bench of retorts made up of horizontal and vertical rows. In present practice the retorts are charged by hand, and although the workingmen receive the wages of high-skilled labor the charging is often uneven and uncertain.

Roasting Furnace.—Frank Klepetko (811,643, Feb. 6) patents a modification of his system of cooling the rabble-shaft and arms in a McDougall roasting furnace. The object is to constrain the circulating cooling medium to remain in contact with the walls of the rabble-shaft for a maximum length of time. For this purpose the rabble-shaft is divided into two longitudinal contiguous intercommunicating conduits, the cooling medium passing through the shaft in one conduit in one direction and through the other conduit in the opposite direction.

Tin.

Production of Stannic Chloride Solutions.—Like other electrolytic alkali and bleaching powder plants, the Acker Process Co., of Niagara Falls, has made for several years extended experiments with a view of utilizing their chlorine to better advantage than is possible in the manufacture of bleaching powder at the present market price. Chas. E. Acker (810,897, Jan. 30) proposes to prepare stannic chloride solutions as follows: Certain tin salts, in which the tin is in the tetravalent state, are extremely energetic solvents for metallic tin, whereby the solvent liquid is reduced to the divalent state and looses its solvent power for tin. By bringing the liquid into contact with chlorine gas, it is raised again to the tetravalent condition, with corresponding restoration of its solvent power. This regenerated solvent is again brought into contact with metallic tin and again regenerated, the operation proceeding in this manner until the required concentration is reached. In this way stannic chloride solutions of high concentration and uncontaminated by impurities of any kind may be produced. This is one process of Acker. A second process starts with a stannic chloride solution produced in this way and having a specific gravity of at least 1.8. If this is converted to a stannous chloride solution by contact with metallic tin, the stannous chloride will separate out in form of crystals of a high degree of purity; and if the stannous chloride solution is formed at a temperature of about 50° or 60° C., a large yield of the crystals will be obtained when the solution is permitted to cool. Acker proposes not to use pure electrolytic chlorine gas, but to mix it with a large proportion of air (even as much as 95 to 96 per cent of air), and to inject steam into the chlorine for the production of hydrochloric acid. Since the reaction evolves considerable heat, a portion of the heat is absorbed in raising the temperature of the excess of air, and it is, therefore, possible to utilize larger absolute quantities of chlorine in a given time. The addition of hydrochloric acid results in the acceleration of the solvent action of stannic chloride upon metallic tin and also prevents the formation of oxychlorides of tin. The patent above referred to describes apparatus for carrying out these processes.

Aluminium.

Soldering Aluminium.—A. W. King (811,725, Feb. 6) patents a special solder by means of which it is possible to "unite aluminium coated therewith to either aluminium similarly 'tinned' or to another metal coated with ordinary solder, the connection between the two coated surfaces in either case being then practicable by means of ordinary commercial soft solder." The preparation of the special solder is as follows: Soft

solder, composed of one part of tin and two parts of lead, is melted together with zinc and aluminium in the following proportions by weight: Ten parts of soft solder, five of pure zinc and five to eight of aluminium. This mixture is melted in an iron pot to a low red-heat, and then poured into a mold. For soldering aluminium to aluminium the surfaces are first cleaned by scraping and heated. The special solder is then rubbed thereon until it adheres, and the coated surfaces are then cleaned. The two pieces can then be united by using ordinary soft solder, no spirits or resin being required to enable the ordinary solder to adhere to the above special solder. To solder any other metal, f. i. brass, to aluminium, the aluminium piece is coated with the special solder, as above described, while the brass piece is coated in the usual way with soft solder and either hydrochloric acid, neutralized with zinc or resin, and then carefully cleaned and washed. The two pieces are then soldered by ordinary commercial soft solder with application of heat. The special solder, when prepared according to the above recipe, must be kept clean and free from grease, and must not come in contact with mercury.

BOOK REVIEW.

SECOND-YEAR CHEMISTRY. By Edward Hart, Easton, Pa.: The Chemical Publishing Co. Price $1.25.

Prof. Hart has given the student of chemistry an excellent aid in his recent volume, although it seems to us that good manuals of qualitative analysis are already sufficiently numerous. This book is to be praised because it co-ordinates some of the methods of quantitative work with second-year work in the college laboratory. Such is undoubtedly the proper method of instruction.

A Low-Resistance Thermo-Electric Pyrometer.

At the reunion of the American Society of Mechanical Engineers, held on Jan. 30, Prof. William H. Bristol, of the Stevens Institute of Technology, described and exhibited his new and very interesting thermoelectric pyrometer, suitable for temperatures not to exceed 2,000° F.

The pyrometer is of the Le Chatelier type, but differs from the instrument of the French scientist in the nature of the alloys employed for the couple and in several mechanical details which were devised to increase the convenience of the use of the instrument for practical use. With the platinum and platinum-rhodium couple of La Chatelier an extremely delicate high-resistance galvanometer is practically indispensable. Le Chatelier considers 200 ohms as the minimum resistance allowable in the indicating instrument. This amount of resistance is necessary to eliminate the atmospheric temperature influence upon the whole resistance. Contrarywise with the Bristol pyrometer a low-resistance instrument is used. The British pyrometer consists of three parts, the couple, the indicator and the leads, connecting couple and indicator. The leads between the couple and the indicator may be of almost any desired length to meet the special requirements; the combined resistance of the leads, couples and indicator are fixed to suit the total range of the instrument, and varies from 3 ohms as a minimum to 10 as a maximum. The indicator is a low-resistance instrument of special design,

FIG. 1.—SWITCHBOARD TYPE OF PYROMETER.

and is made especially for this purpose by the Weston Electrical Instrument Co.

Fig. 1 shows a wall or switchboard form of the indicator. Fig. 2 illustrates a portable form.

FIG. 2.—PORTABLE TYPE OF PYROMETER.

Prof. Bristol made a long series of experiments with different metals and alloys so as to find a couple which would withstand a high temperature and at the same time give a high thermo-electromotive force. The couples finally adopted by him consists of alloys of tungsten, steel, nickel, iron and copper, different alloys being employed to suit the total ranges of temperature that it is desired to have the scale cover.

Since no rare metals are used for these couples this part of the pyrometer is inexpensive, and it is possible to employ elements of large cross-section which will not be affected in their resistance any appreciable amount by the variation of temperature along the lengths of the elements forming the couple.

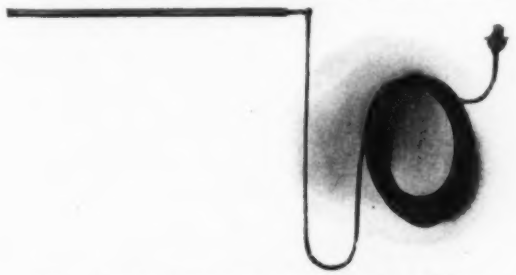


FIG. 3.—THERMO-ELEMENT, JOINT, LEADS AND PLUG.

The leads to the indicator are made of flexible insulated copper duplex cable and of ample cross-section to practically eliminate the influence of variations of atmospheric temperature.

The cross-section of the elements of the couple is reduced at their junction, thus rendering it sensitive to sudden changes of the temperature to be measured.

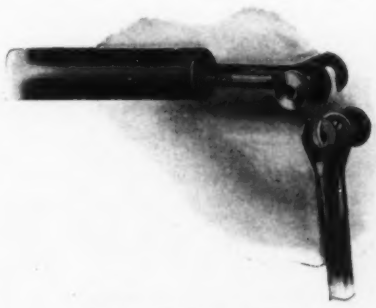


FIG. 4.—DETAILS OF JOINT.

A novel feature of the couple is that it is made separable at the point where it passes through the wall of the space within which the temperature is to be measured.

The object of the joint is two-fold: first, to make it possible to renew the "fire-end" whenever it may be necessary; and, secondly, to permit carrying the cold ends of the elements to a point toward the floor, where the atmospheric temperature will be constant and not influenced by the temperature that is being measured.

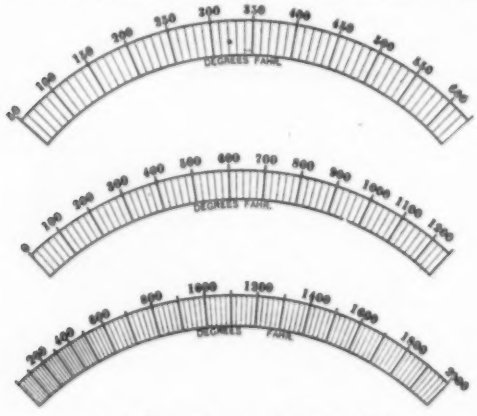
Fig. 3 shows a complete element with separable joint, coiled leads and lamp plug on the end of the cable forming the leads, for convenient connection to the indicating instrument shown in Fig. 1.

A special feature of the joint is that it is provided with large bearing surfaces to prevent possibilities of variations of resistance at the connection, and is constructed to allow for easily breaking and making the connection. The details of the joint are shown clearly in Fig. 4, and from this it will be seen that it is impossible to make connection incorrectly, as is usually done when there is nothing to guard against it.

The low cost of the couples makes it practicable in the use of the instrument to keep an extra fire-end in reserve, which may at any time be quickly substituted for the one that has been in continual service, thus affording an economical and positive check upon the accuracy of the instrument.

The elements of the couple are independently insulated in a novel and effective manner by winding each with asbestos cord and then coating the surface with carborundum paint, a solution of silicate of soda being used as a binder. This makes a clean, compact and smooth insulation.

Couples thus insulated are flexible, and can either be applied to the heated space directly or they may be insulated in a piece of ordinary pipe as a protection. This protection has proven itself to be effective and economical. For continuous applications of the couples to temperatures in the neighborhood of 2,000° F., or over special protecting tubes of nickel, plumbago or porcelain are employed.



FIGS. 5, 6, 7.—SCALES OF INSTRUMENT.

Figs. 5, 6 and 7 show the scales up to 600°, 1,200° and 2,000° F. For very open scales over shorter ranges several couples may be placed in series, thus making it possible to read to small fractions of a degree.

A novel application of the thermo-electric couple is that of determining the temperature of molten metals, as cast iron, copper, brass and bronze. It consists in leaving the ends of the elements disconnected and without insulation.

When these ends are slightly immersed in the molten metal it makes a junction between the elements, and the reading will be the same as if the elements of the couple had been originally joined. The advantage of this plan is that the reduced cross-section at the ends of the couple allows it to almost instantaneously attain the temperature of the molten metal, and consequently there is no time-lay error—a most important advantage. As the couple is used over and over again, the ends become worn away, but the couple is, nevertheless, always ready for use by immersion of a fresh portion, which will not be changed in any way by continued use, and will give the same reading for a given temperature as if the couple had not been worn away. A joint is provided near the end that is immersed so that a fresh tip can be applied to the couple before enough of the end has worn away to appreciably affect the resistance of the complete system.

Compensators.

For refined measurements it is necessary to allow for changes of temperature at the cold end of the couple unless some means is provided to maintain it at a constant temperature.

This is done by Prof. Bristol in a most ingenious and simple way by the compensating device shown in Fig. 8. It consists of a glass bulb with a short stem, similar to an ordinary mercurial thermometer. Two platinum terminal wires are fused into the stem near its top. These are connected within the bore of the stem by a loop of fine platinum wire, thus completing the circuit as indicated in the diagram.

The size of the bulb, the cross-section of the bore of the stem and the cross-section of platinum wire loop are proportioned to suit the case in hand.

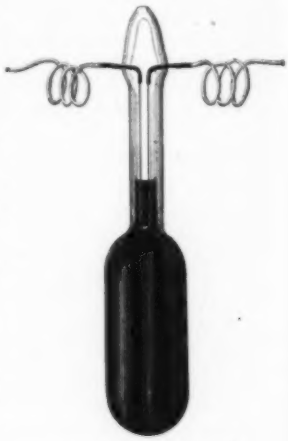


FIG. 8.—COMPENSATOR.

The compensator will perfectly compensate for any particular point on the scale, as, for instance, the working point where it may be desired that the reading shall be absolutely independent of changes of temperature at the cold ends. It will readily be seen that if the temperature rises at the cold end the mercury rising in the stem will short-circuit a certain portion of the platinum loop, thus reducing the resistance of the entire circuit by exactly the necessary amount, so that the diminished electromotive force of the couple, due to the rise of temperature of the cold end, will send the same amount of current through the circuit and instrument, and consequently give the same reading as if there had been no change of temperature at the cold end.

Fig. 9 is a diagrammatic sketch showing the compensator connected in circuit.

In summing up the features of his new pyrometer, Prof. Bristol emphasized the following chief advantages:

First, the commercial switchboard type of portable dead-beat indicating instrument may be employed, instead of the extremely delicate suspension-galvanometer required for use with a single platinum-rhodium couple. This advantage is gained by the fact already stated, that the thermo-electric couples employed give several times as much electromotive force as the platinum-rhodium couples, which is ample to successfully operate a pivot instrument if of sufficiently low resistance.

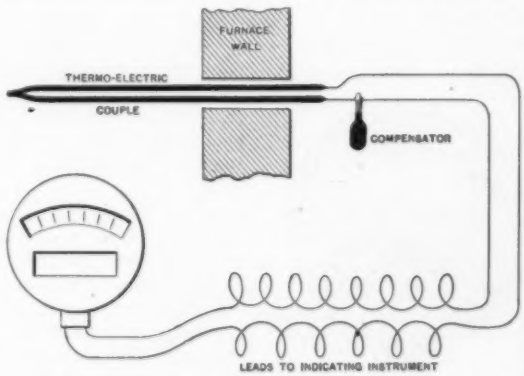


FIG. 9.—DIAGRAM OF CONNECTIONS WITH COMPENSATOR IN CIRCUIT.

Secondly, it affords a practical method for automatically

compensating for the changes of temperature at the cold ends of the couple, as already described.

Thirdly, it makes it practicable to use the same indicating instrument and the same couple for different total ranges of temperature by using different binding posts and having several scales drawn, the proper resistances being inserted for each individual total scale.

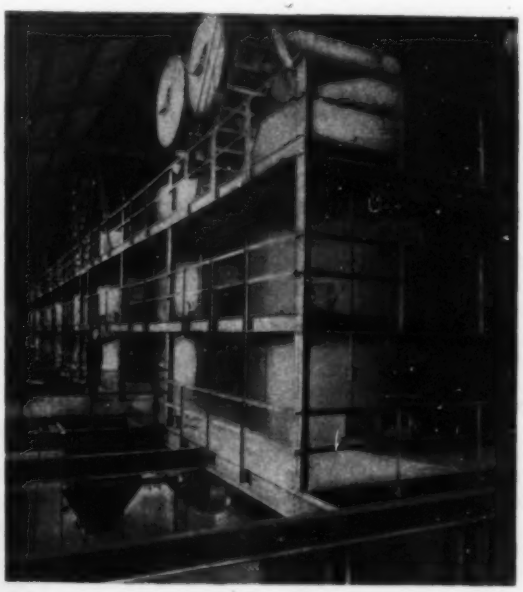
This new pyrometer is made by William H. Bristol, 41 Dey Street, New York City.

A New 1000-Ton Concentrating, Roasting and Smelting Plant.

The Nevada Consolidated Copper Co., San Francisco, whose properties are located near Ely, Nev., where a new 1,000-ton concentrating, roasting and smelting plant is in process of construction, has recently let the contracts for the entire equipment, including power and electrical apparatus, to the Allis-Chalmers Co., of Milwaukee.

The new works, when completed, will constitute one of the most carefully equipped and thoroughly modern plants in the United States. Up to the present time the work on the company's properties has been largely that of development, awaiting the completion of a plant with adequate capacity to handle the output. The process of treatment will consist in the concentration of ores, which concentrates will be passed to the McDougal roasters, and thence to the reverberatory furnaces and converters in the usual manner.

In laying out the plant the arrangement of equipment of various kinds follows closely the process referred to. It is divided into departments under the following heads: 1. Concentrating machinery. 2. Roasting machinery. 3. Reverberatory smelting machinery. 4. Converter machinery.



ROASTING PLANT OF ANACONDA COPPER CO.

Under these divisions the ore-treating machinery, much of which is of special and unusually heavy design, aggregating 2,800,000 pounds in weight, will be installed.

One of the features of the new plant's equipment will be the battery of six McDougal roasting furnaces, each standing 19 feet, 6 inches high and 18 feet in diameter. The main shafting for the entire group of six furnaces will be driven from a 20-horse-power Bullock induction motor, running at a speed of 850 r. p. m. The operator will be enabled to control the operation of each furnace from any one of three floors or stages about them.

The McDougal roasting furnaces are of the well-known construction shown in the adjoining illustration, which is given here on account of its inherent interest, although it has no further connection with the plant of the Nevada Consolidated Co., The illustration is an interior view of the Anaconda Copper Mfg. Co.'s roasting plant—the largest in the world—where fifty-six McDougal furnaces are installed.

The list of concentrating machinery to be installed at the Ely plant will include, among other appliances, six 6-foot Huntington mills, specially heavy in design, of the Anaconda type. They will be equipped with special step-box and continuous shaft for three mills, dividing the six mills into two groups, also two heavy-design Blake crushers, eight Overstrom tables, ninety-one vanners, and twenty-four "Richards" classifiers, designed under the direction of the inventor, Prof. R. H. Richards, of the Massachusetts Institute of Technology.

The engine equipment consists of two 22-inch and 48-inch x 48-inch compound condensing heavy duty type, a blowing engine, with cylinders 16 inches x 32 inches, to deliver 6,000 cubic feet of free air per minute, and electrical machinery as follows: Two 800-kw. Allis-Chalmers "Bullock" engine-type alternators, two exciters and seven motors, ranging from 20 to 100 horse-power for the operation of the various ore reducing devices, furnaces, etc.

Mr. Thomas W. Cox is engineer of the company. It is expected that the new plant will be ready to begin operations by early summer.

Water Gas in the Manufacture of Incandescent Lamps and Storage Batteries.

Water gas has been used for several years with an enormous economy as compared to illuminating gas in European lamp factories for glass-blowing and carbonizing filaments and in storage battery factories for lead soldering. The most prominent European manufacturers of lamps and storage batteries use the latest German type of water-gas producers, by which a far greater yield of gas is claimed to be obtained than with the water-gas plants that are used in this country, which are similar to the older German type.

Water gas is made by alternately blowing steam and air through glowing coke. By blowing air through the coke (hot blowing period) the latter gets sufficiently hot so as to decompose the steam during the gas-making period.

In the decomposition of steam hydrogen is liberated, the oxygen forming carbon-monoxide with the carbon of the coke. Such a mixture of equal volumes of hydrogen and carbon-monoxide with a small amount of impurities is the commercial water gas. The decomposition of steam is absorbing heat, so that after a certain length of time a cooling off of the coke is taking place. The coke is now not hot enough to decompose the steam entirely, and at last the steam will go through the fuel undecomposed.

The object of a good and efficient water-gas process is to increase the time of gas making to a maximum, and to decrease the time of hot blowing to a minimum.

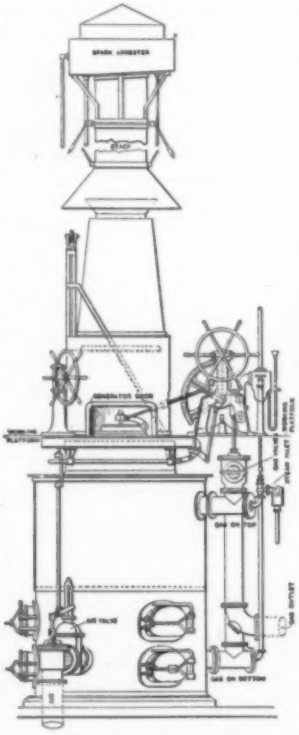
In the producers in use in this country and in the older German processes a high layer of fuel is used in the producers, and a low air pressure is applied during hot blowing. The best results obtained by these systems was a gas-making of 4 to 5 minutes. After 4 to 5 minutes of gas making the heat of the coke decreases to such an extent that gas making had to be stopped and "hot blowing" done for 4 or 5 minutes, after which hot blowing the gas making is started again.

The product of combustion of the hot-blowing period is a low-grade producer gas which has to go to waste in most places, and can be utilized only under certain local conditions. The problem to be solved by the water-gas engineers was to

generate, during the hot blowing, a gas practically free of carbon-monoxide and high in carbon-dioxide, as by burning the coal to carbon-dioxide four times as much heat is generated as by burning same to monoxide. By burning to dioxide, in a certain time, four times the heat is generated as by burning to monoxide, and the hot blowing reduced to one-fourth or less. This has been successfully accomplished in Germany by using a low layer of fuel and high-pressure blast, and there are now over 200 plants working in Europe successfully for the last five years.

In these plants gas is made for 8 minutes and air blown for 1 minute. It is apparent that with such a producer of certain size the yield is largely increased as compared with the old type, and is in fact 35 to 40 cubic feet of gas of 275 to 285 B. T. U. per pound of coke.

By decreasing the period of hot blowing, as above stated, only a small holder is required so as to hold sufficient gas to help over the hot-blowing period, while in the older systems a very large holder had to be used, the cost of which, as a rule, amounted to more than the cost of the water-gas plant proper.



WATER-GAS GENERATOR.

Since the development of this system water-gas plants have been erected and are in successful use not only for electrical industries, but also for welding, annealing, brazing, forging, chemical factories, etc., in fact, wherever high temperatures or good regulation of same are required.

The working of the water-gas generator is as follows: The generator, which is a cylindrical shell, lined with fire-brick and provided with the necessary valves for entrance of air, etc., is filled with coke to a certain height, and blown hot by means of a positive blower. During this period the air inlet valve and the charging door leading to the flue are kept open; the gas valves are closed. The air enters under the grate and goes through the fuel to the stack. When the generator is sufficiently hot the air inlet and the charging door are closed, and at the same time the upper and lower gas valves are opened, depending where the gas is to leave the generator. Then steam is blown into the fuel until the gas gets inferior, which can be seen from a test flame.

When the quality of the gas deteriorates the steam valve is closed, the air valve and charging door are opened, the gas outlet closed and the blower started. This way air and steam is blown in from the top and from the bottom, for making the distribution of the heat in the generator more uniform. Fuel is charged through the charging door after three times of gas making. The generator is provided with tight doors, through which clinkers and ashes are removed.

The air and gas valve are interlocked, so that they cannot be opened at the same time; when the air valve is opened the generator is locked and *vice versa*. This insures absolute safety. The generator and all the valves are worked from the platform.

The water gas, after leaving the generator, goes to the scrubber, which is filled with coke and sprinkled with water; from here the gas goes to a small holder, which serves as an equalizer.

In this country such water-gas plants are built by Dr. Oskar Nagel, 90 Wall Street, New York City.

Notes.

Bethlehem Steel Co.—The Bethlehem Steel Corporation now employs 11,000 men. It is proposed to devote the proceeds of the sale of $12,000,000 of bonds to enlargement of the plant to a capacity that will employ double the number of men now on the pay roll. A year and a half is the estimated period within which the new work will be completed.

Metallurgie.—Prof. W. Borchers' well-known journal entitled *Metallurgie*, which is now in its third year, and which in the first two volumes dealt essentially with metals other than iron, has now, beginning with the third volume, extended its scope so as to include iron and steel. The editors are now Prof. W. Borchers, for all metals other than iron, and Prof. F. Wuest for iron and steel.

Protective Paint.—According to recent reports the Carbondale Machine Co. are successfully applying crysolite for painting brine and ammonia pipes, steam and ammonia condensers, brine and water tanks. It is said to meet in every respect the purpose of an elastic and strongly adhesive paint which will not become loosened when exposed to extreme ranges in temperature or to the action of acids or alkalies. Fuerst Bros. & Co., of New York, are distributing agents for the manufacturers, the Semet-Solvay Co.

Battery Exhibit.—At the Chicago Electrical Trades Exhibition, held from Jan. 15 to 27, the General Storage Battery Co. showed, in addition to a full line of Bijur "high-duty" plates and batteries, a working booster system handling violently fluctuating loads while maintaining a steady load on the generator. This is accomplished by a Bijur automatic regulator working on a new principle.

Electric Power in the South.—The Westinghouse Electric & Mfg. Co. have recently closed a contract with the Southern Power Co., at Charlotte, N. C., for a large and complete power equipment, consisting of eight 3,000-kw. water-wheel type alternators, with a complement of transformers, exciters and switchboards. This is the largest contract for electrical apparatus placed in the South for some years. The Southern Power Co.'s plant being situated in the midst of the cotton mill district will open up opportunities for the use of electric drive by the surrounding cotton mills and other industrial plants, which have heretofore been impossible, because of the lack of cheap electric power in that vicinity. The Southern Power Co. has full assurance that the cotton mills and other industries in the adjoining territory will make liberal use of the cheap power thus placed at their disposal, it being recognized that electric drive not only increases both the reliability and efficiency of a plant, but at the same time decreases the cost of production, and insures a better quality and a larger output of material.

Water-Wheels.—We have received from the Abner Doble Co., of San Francisco, their new catalogue entitled "Doble Tangential Water-Wheels." The first portion contains a general description of the essential features and parts entering into the construction of the water-wheels built by this firm, special attention being paid to the Doble needle regulating nozzles, ellipsodial buckets, ring-oiling bearing, nickel-steel shafts, etc. Illustrations of several of their different types of water-wheels are followed by descriptions of some of the typical hydroelectric power plants in which Doble water-wheels are operating. Some of these are very interesting,

thus the 8,000-hp. wheels which have been constructed by this firm for the de Sabla and Electra power houses and the 9,000-hp. wheel now being built. The Cornell plant is interesting on account of the high efficiency, 84.5 per cent, obtained on the Doble wheels. The latter portion of the book contains water-wheel tables covering all the conditions of water-power up to a head of 2,500 feet, and in capacities up to 5,000 hp. Other tables relate to the loss of head in pipe friction, riveted steel pipe, etc. The last seven pages are devoted to a series of ready conversion factors, most of which have been compiled from a recent book of Mr. Carl Hering. On account of the large amount of information contained in it the catalogue really represents a handy hydraulic engineering reference book.

Chemistry and Rats.—On the editorial pages of a recent issue of the London *Electrician* the following note appears: "It has sometimes been said that we have too much experiment now, and that accumulating piles and piles of undigested facts does not help science much. But there are exceptions which are quite outside any carping criticism. Who would deny the utility of this formula: $\text{Log } N = \frac{1}{4} [0.233 + (3 \times \text{log B. W.})]$?

It is hardly necessary to add that B. W. is the body weight of a white rat, and N is the total nitrogen in milligrammes per diem excreted by white rats differing in age and weight—and, perhaps, in religious opinions. All the information, but the last item, is in an abstract to be found in the November *Journal* of the (British) Chemical Society, p. 740. We have not seen the original paper; doubtless it will be out of print by this time. The compilers of technological pocket-books will have swooped down upon it and bought all the available copies."

Engines.—The Allis-Chalmers Co. has in preparation for its power department bulletin No. 1504, on heavy-duty engines. Although the heavy-duty horizontal engines, manufactured by Allis-Chalmers Co., may be seen in operation in so many public and private power plants that few who desire to investigate their construction need have recourse to a descriptive bulletin, yet this is now to be issued for the convenience of prospective customers, and it will naturally embody the latest features of design. The bulletin is one which will appeal not only to engineers in charge of power plants, but also to the owners of such, who may not have much information concerning technical details of operation, yet can understand "results."

Tube Mills for Wet Crushing.—The Allis-Chalmers Co. has in preparation for its mining and crushing machinery department a new bulletin (No. 1,410) on tube mills for wet crushing in mining works. This is a publication which should be of considerable value to mine owners, particularly those who have properties yielding low-grade ore, for it gives the results of tests made by some of the leading companies in the South African fields to determine how far they can benefit by the introduction of tube mills as fine pulverizers working upon the product of their stamp batteries. The figures given are not only interesting but will probably surprise many mine owners in this country who have not paid much attention to the possibilities of tube mills in ore reduction work. Tests at some of the mines on the South African Rand showed, for instance, that a yearly increase in profit of from 15 to 40 per cent could be effected by the use of tube mills as auxiliary crushers. The data given in the bulletin may be regarded as absolutely authentic, inasmuch as they have been taken from official reports made at directors' meetings of the mining companies referred to. We have repeatedly referred in our columns to the introduction of the tube mill into practical gold metallurgy.

Belted Alternators.—The Allis-Chalmers Co. will issue, shortly, for its electrical department, bulletin No. 1,051, on alternating-current generators of the belted type. While direct-connected alternators have largely displaced belted machines in modern power stations, there are many places, particularly in comparatively small installations, where belted units are desired. Belted machines are easily connected to the existing source of power as, for example, a line shaft used for driving other machinery, and for these installations of lesser size they are lower in first cost than direct-connected apparatus. The Bullock machines described in this bulletin are adapted to a wide range of output.

Machinery for Cement Making.—When at the recent Bethlehem meeting of the American Institute of Mining Engineers an excursion was made to the Atlas Portland Cement Co., and later to the Lehigh Portland Cement Co., those visitors who were not familiar with the advances of the cement industry of the Lehigh Valley during the last fifteen years, were struck by the enormity of the plants and the skillful design of the machinery employed in the various steps of cement making. It is now recognized that the phenomenal progress in the Portland cement manufacture set in when it had been learned how to turn out a uniform product. Of course, this knowledge came hand in hand with the improvement in machinery. The visit to the above named two plants was also instructive in showing quite essential differences in the mechanical equipment of both, while the product of both of them is excellent. A useful and profusely illustrated description of up-to-date cement-making machinery has just been issued as a pamphlet of the Allis-Chalmers Co., of Milwaukee (catalogue No. 1,291), dealing concisely, yet fully, with rock breakers, crushers, dyrers, kilns, ball mills, tube mills, elevators and conveyors, and in general with all kinds of machinery for every stage in cement making by either the wet or dry process. The Allis-Chalmers Co. is the largest manufacturer of cement-making machinery. During the year 1903, when the total production of Portland cement in the United States was a little more than 20,000,000 barrels, the Allis-Chalmers Co. sold cement-making machinery capable in the aggregate of turning out 5,000,000 barrels of finished cement per year.

Silver.—According to the Mint figures, the supply of silver from all available sources in 1904 was 176,840,014 ounces, as against 173,222,088 in 1903. This was an increase of 3,617,926 ounces, or a gain of 2.1 per cent. Mexico was the heaviest contributor, with an output of 60,808,879 ounces, although this shows a decrease of more than 7,000,000 ounces from the output in 1903. The United States was second with a total of 57,786,100 ounces, against 54,300,000 a year earlier, a gain of 3,486,100 ounces, which almost equals the entire world's gain for the year. Australia was third, with a record of 14,558,892 ounces, against 11,909,040 ounces in 1903.

Fixation of Atmospheric Nitrogen.—In our January issue we referred on page 24 to commercial developments in connection with the Birkeland-Eyde process at Arundal, Norway. Concerning the principal features of the process see our Vol. II., pp. 399 and 507, and Vol. III., p. 33. O. N. Witt gives some additional information in *Chemical Industry*, 1905, 28, 699, which is reported in the *Journal Society of Chemical Industry*, 1906, Jan. 15, as follows: The nitrogen compounds are absorbed in towers and the weak acid is used over and over again in the towers until it attains a strength of 50 per cent. The gases leaving the absorbing towers, are next passed through milk of lime and then over dry lime, calcium nitrite being chiefly produced. This is treated with nitric acid, and the nitrous acid evolved is oxidized, the nitric acid formed being absorbed in the absorbing towers. At present the whole of the nitric acid is fixed as calcium nitrate. In accordance with a suggestion by R. Messel, the normal calcium nitrate is converted by addition of quicklime or calcium sulphate into basic nitrate, which forms a practically non-hygroscopic powder of great value as fertilizer. The company believes they can

generate electric power at $3 per horse-power-year. (With respect to this point it may be said that as a matter of fact there are some places in Norway where very cheap water-power is available, although the figure of $3 seems rather too low.)

Electric Laboratory Furnace.—A new laboratory furnace recently placed on the market by the Vereinigte Fabriken für Laboratoriums-Bedarf, of Berlin, uses platinum wires as heating resistances, the same being entirely enclosed within the refractory linings. The arrangement shows a very uniform temperature, and wear and tear or destruction of the platinum crucibles put into the furnace is impossible. When wet deposits are to be heated in the crucible, it is preferable to first place a triangle of fused silicate glass into the furnace, so that the crucible does not rest directly on the bottom of the furnace. There is sufficient space for crucibles up to 30 cc. volume. The furnace is built for voltages between 65 and 220. For very accurate quantities of work the inside walls of the furnace are covered with platinum, in order to prevent small pieces of the refractory linings from dropping down. The Laboratory & School Supply Co., which has been a New York branch for the Vereinigte Fabriken für Laboratoriums-Bedarf, of Berlin, Germany, have recently combined their business with that of the Kny-Scheerer Co., department of laboratory supplies, 225-233 Fourth Avenue, New York.

Industrial Chemistry in the South.—At the New Orleans meeting of Section C of the American Association for the Advancement of Science and of the American Chemical Society, Mr. C. A. Browne, Jr., spoke of recent developments of industrial chemistry in the South, and especially in Louisiana. The developments in the fertilizer industry, manufacture of ice, preservation of wood, distillation of turpentine, tar, methyl alcohol, etc., from wood and the utilization of wood waste for the manufacture of methyl alcohol by Classen's process were briefly discussed. The utilization of cotton-seed by-products in a number of new ways was alluded to, and reference was made to a new process for extracting oil from rice and the improvement of the rice by-products for cattle feeds. The remainder of the paper was devoted to a discussion of recent developments in the sugar cane industry, particular stress being laid upon the recent work in improving the varieties of sugar cane and in the utilization of the by-products of the sugar house—the bagasse and molasses.

Pressed and Seamless Steel Specialties.—Messrs. Janney, Steinmetz & Co., of Philadelphia, have recently issued a catalogue showing various applications of seamless cold-drawn steel, high-pressure reservoirs, boiler shells, domes, tanks, tubes, cylinders, special drawn and forged shapes in seamless steel, etc. This is an art that has lately developed tremendously.

Gas Power.—The Westinghouse Co. has recently issued very neat and fully illustrated reprints of the following papers, which contain much useful information on gas power; two papers, by A. West and J. R. Bibbins, on gas power in electric railway work, and a paper by J. R. Bibbins on gas power for high-pressure city fire service.

Illinois Water-Power.—The famous case of the State of Missouri *vs.* the State of Illinois, involving the right of the city of Chicago to divert its sewage into the Mississippi River through the Chicago sanitary canal and the Illinois River, has just been decided by the Supreme Court of the United States in favor of Illinois. This decision leaves the way clear for the power development project, which is well in hand, for using the 40,000 hp. in water-power at Lockport, Ill., the lower end of the sanitary and ship canal. At this point will be installed four 4,000-kilo-volt-amp., three-phase, 60-cycle, 6,600-volt alternating-current generators, now under construction in the shops of the Crocker-Wheeler Co., Ampere, N. J.

Personal.

Mr. Benjamin Magnus, former superintendent of the Anaconda electrolytic refinery, and for the past two years with the Calumet & Hecla Co., at their Buffalo smelting works, has resigned his position on Feb. 15, when he left immediately for California, to take charge of special work for the Mountain Copper Co., Ltd., at their new smelters at Martinez, Contra Costa County, Cal.

Mr. Albert Ladd Colby has just sent out cards announcing that he has opened an office as consulting and inspecting engineer and iron and steel metallurgist. He has postponed the announcement until after the annual meeting of the Association of American Steel Manufacturers, when he resigned as secretary, being ineligible, as he was no longer connected with the steel manufacturers. Mr. Colby has had over twenty years experience in the steel business, for eighteen years of which time he was connected with the Bethlehem Steel Co. He has visited all the prominent works abroad, and was a juror in metallurgy at the Paris Exposition in 1900. For the past three years he was nickel-steel expert for the International Nickel Co. He has written a book on steel specifications, and is a frequent contributor to the technical press and the many scientific societies of which he is a member.

Digest of U. S. Patents.

Prior to July, 1902.

Compiled by Byrnes & Townsend,
Patent Lawyers,
National Union Building, Washington, D. C.

No. 657,937, Sept. 18, 1900, Charles B. Jacobs, East Orange, N. J.

Metallic cyanides are produced by the reaction of nitrogen upon carbides in a porous condition. In one form of the process barium carbide, melted in presence of carbon and distributed over the carbon surfaces, is then permitted to cool below the fusing point of the carbide, and is subjected to the action of nitrogen, which is directly absorbed with production of the corresponding cyanide. In another and preferred form barium carbonate or hydrate is mixed with sufficient carbon to produce the carbide and to leave an excess of carbon, and is subjected to such heat as to produce the carbide; the porous mass is then permitted to cool and subjected to the action of nitrogen as above. In either case an electric furnace of the rotary type is preferably used, tuyeres being provided for injecting nitrogen into the porous mass at some distance from the electrodes. It is stated to be essential to the best efficiency that the fused carbide shall be permitted to solidify by cooling before being subjected to the action of nitrogen. The process is applicable to various cyanides, but the reaction occurs with especial facility with barium carbide. The barium cyanide produced may be separated from the excess of carbon by solution, crystallized, and either used directly or converted by known methods into the alkali metal cyanides.

No. 657,938, Sept. 18, 1900, Charles B. Jacobs, East Orange, N. J.

An improvement on the method of 657,937, relating to the steps whereby the barium carbonate is obtained in more intimate mixture with the coke. To this end barium carbonate is mixed and finely ground with an amount of coking-coal sufficient to furnish an excess of carbon over that required for the manufacture of barium carbide, the preferred proportions being three parts by weight of barium carbonate to two parts of soft coal. This mixture is coked in an ordinary retort oven, and is thereafter transferred to the electric furnace for conversion into cyanide in the manner described in patent 657,937. It is stated that a furnace producing 1 ton of product per day requires a current of about 1500 amps. at 100 volts.